117544

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, OMAHA DISTRICT
215 NORTH 17TH STREET
OMAHA, NEBRASKA 68102-4978
September 3, 1991

REPLY TO
ATTENTION OF

Environmental Branch

Mr. Brad Bradley (5HS-11)
U.S. Environmental Protection Agency
Region V
230 South Dearborn Street
Chicago, Illinois 60604

Dear Mr. Bradley:

Enclosed are three copies of the Final Scope of Services for the NL Industries/ Taracorp Superfund Site, located in Granite City, Illinois. The Notice-to-Proceed will be issued within the next month. The field investigation is scheduled to commence in October, with the submittal of the Draft Pre-Design Report in March 1992. Initiation of Remedial Design is anticipated in January 1992, and Remedial Action is scheduled to begin in November 1992. Detailed project schedules are currently being developed.

These three copies are for your files. The U. S. Army Corps of Engineers is anxious to commence this Superfund study, and we look forward to working with you.

If you have any questions, please call Mrs. Terry Buchholz at telephone (402) 221-7654.

Sincerely,

Randal K. Petersen, P.E.
Chief, Environmental Branch
Engineering Division

Enclosure

Contract No. DACW45-90-0008
Final Scope of Services
NL Industries/Taracorp
Granite City, Illinois
Pre-Design Work
22 July 1991

1. Objective. The purpose of this work effort is to conduct the pre-design field investigation and sampling for the remedial design of the corrective action for the NL Industries/Taracorp Superfund site. The Record of Decision (ROD) for this site was signed by the Regional Administrator on March 30, 1990. The U. S. EPA Scope of Work for Remedial Design and Remedial Action , the Final Record of Decision, any additional guidance provided by U. S. EPA shall be used as references. This Scope of Services (SOS) implementing the pre-design action will be followed.

2. Scope of Services. The Pre-Design work shall be conducted in accordance with this Scope of Services and in a manner to result in adequate information for the remedial design required in the ROD. Soil and battery case material sampling/inspection shall be performed in the areas indicated below to provide necessary data for the remedial design (to be accomplished under a separate contract).

3. Areas of Concern.

3.1 Area 1. Area 1 consists of property owned by Trust 454 and Tri-City Trucking. Trust 454 property contains a pile of battery case materials (SLLR pile) as well as unpaved areas. Soil and battery case material sampling/inspection shall be conducted in all unpaved areas in Area 1 including the material which is beneath the SLLR pile. (The SLLR pile will be consolidated with the Taracorp pile). The depth of excavation to which Area 1 must be excavated to achieve a 1000 ppm cleanup level shall be determined in this pre-design work. Area 1 is shown on Figure 1.

3.2 Residential Areas. All residential portions of Areas 2 through 8 and immediately adjacent properties, shall be soil sampled to determine the depth to which each individual residential yard must be excavated to achieve a 500 ppm soil cleanup level. Inspections of alleys and driveways and areas containing surficial battery case materials in Eagle Park Acres, Venice, Granite City, Madison, and other nearby communities shall be conducted to determine which specific areas not already identified in Figures 1,2, and 3 need remediation. TCLP representative testing for lead shall be conducted for all areas identified through these inspections as well as areas found in Figures 1, 2, 3, and 4. Lead sampling of all identified areas which are not alleys or driveways shall be conducted to determine the depth to which such areas must be excavated to achieve a 500 ppm cleanup level. Areas 2 and 3 are shown on Figure 1. Areas 4 through 8 are shown on Figure 2. Eagle Park Acres is shown on Figure 3. Venice is shown on Figure 4.

3.3 Mapping. Based on the soil and battery case material sampling/inspection, an accurate mapping of all residential areas around the superfund site and in Eagle Park Acres, Venice, Granite City, Madison, and other

nearby communities with a lead concentration greater than 500 ppm shall be provided. Refer to Figure 5 for an estimate of these areas.

3.4 Home Interior Inspection. During the sampling/inspection in the residential areas, an inspection of the interior of each home shall be conducted to identify possible sources of lead exposure. The following observation should be made at a minimum: (1) Is there paint peeling in the house? (2) Is there lead piping or lead solder joints? (3) In what condition is the house? The results and recommendations of each inspection shall be provided verbally to the appropriate residents at the time of the inspection and in a summary report for record.

3.5 Plan for Satisfaction of Permitting. The contractor shall develop and submit for approval a plan which shall include, at a minimum, a comprehensive list of all permits required in conjunction with the remedial action, procedures and estimated time frames for acquiring required permits, procedures and methods to be implemented to ensure compliance with permitting requirements.

4. Project Management. The contractor shall assign an employee who will serve as the Project Manager (PM). This individual will oversee the coordination of the entire project, administer all instructions from the USACE-PM, and obtain answers to all questions from the USACE-PM during and after the work.

5. Travel and Meetings. The contractor shall perform the following travel as part of the contract requirements, and the cost thereof shall be included with contract cost. Responsible representatives of the contractor's firm from the appropriate disciplines shall attend meetings and/or make the trips listed.

5.1 All travel required to obtain field data necessary to complete contract services as detailed.

5.2 To attend meeting at Omaha-COE to discuss final report and results.

6. Review of Progress and Technical Adequacy.

6.1 At any appropriate time, representatives of the Contracting Office (CO) may review the progress and technical adequacy of the Contractor's work. Such review shall not relieve the A-E from performing all contract requirements, except as may be waived by written instructions.

6.2 The contractor, under this contract, will interpose no objection nor restriction to the CO's designation of a contractor for the purpose of reviewing the adequacy and corrections of the work performed under this contract.

6.3 The Monthly Progress Reports. The contractor shall submit monthly progress reports. The progress report shall indicate work performed, schedule revisions (if required), problems incurred during the payment period and steps taken to remedy problems from previous monthly reports.

6.4 Project Schedule. The contractor shall submit an outline of the project schedule for approval five (5) work days after the issuance of the Notice -to-Proceed.

7. Confirmation Notices. The contractor shall be required to provide a weekly

record of all discussions, verbal directions, telephone conversations, etc., participated in by the contractor and/or his representatives on matters relative to this contract and the work. These records, entitled "Confirmations Notices" shall be numbered sequentially and shall fully identify participating personnel, subject discussed, and any conclusions reached. The contractor shall forward to this office a reproducible copy of said confirmation notices. Distribution of said confirmation notices will be made by the Government.

8. Expert Testimony. All technical consultants required for this investigation provided by the contractor will be qualified to provide expert witness testimony, if required. In the event of litigation, the contract will be modified to compensate the contractor for the additional services.

9. Submittals.

9.1 Progress Reports. Submit monthly progress reports no later than the 10th of the month following the reporting period. Submit two (2) copies.

9.2 Draft Report. The draft report shall include all the reporting elements requested below and in the Scope of Services. The Draft Report will be submitted thirty (30) days after completion of the field investigation/sampling. Twenty-two (22) copies shall be submitted. The report will include the results of the field investigation. The following elements will be included in the report.

9.2.1 Mapping. The mapping of the residential property results and Area 1 shall be submitted.

9.2.2 Residential Inspection Report. The results of the inspection of the interior of the residences shall be submitted. EPA must review the Residential Inspection Reports prior to release to the homeowners.

9.2.3 Plan for Satisfaction of Permitting. This plan shall be submitted.

9.4 Final Report. The Final Report will be submitted thirty (30) days after receipt of the review comments. Twenty-two (22) copies shall be submitted.

10. Specific Instructions.

10.1 Health and Safety Scope of Work.

10.2 Chemistry

10.3 Site Specific Chemistry

10.4 Geology and Geotechnical

10.5 Surveys and Mapping

11. Reference Data Furnished.

11.1 Scope of Work for the Remedial Design and Remedial Action

11 .2 Declaration for the Record of Decision, March 1990.

11.3 Remedial Investigation, September 1988.

11.4 Feasibility Study, August 1989.

11.5 Addendum to Draft Feasibility Study, January 10, 1990.

Figure 1

GRANITE CITY SITE
GRANITE CITY, ILLINOIS

Areas 1, 2, and 3

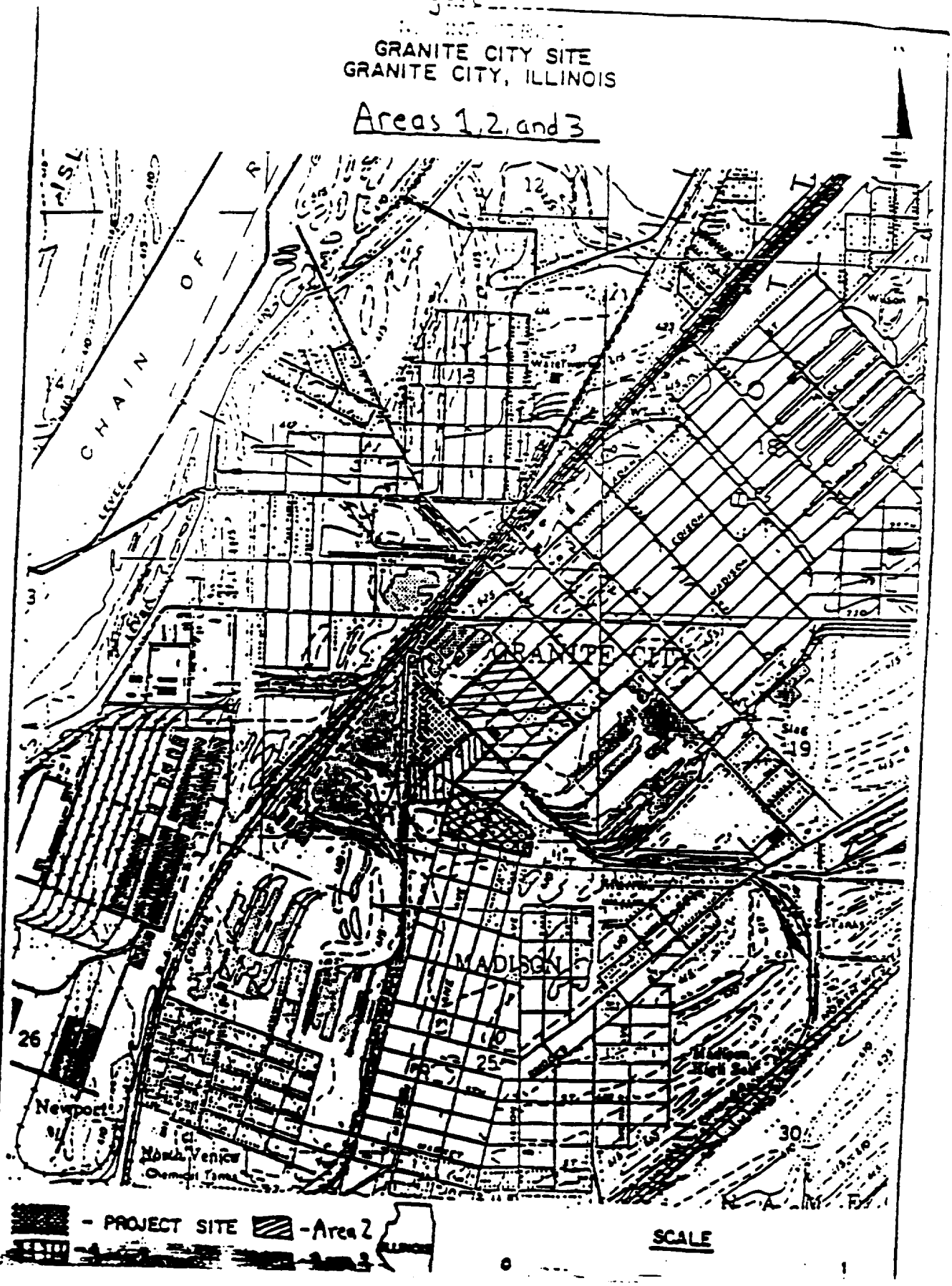
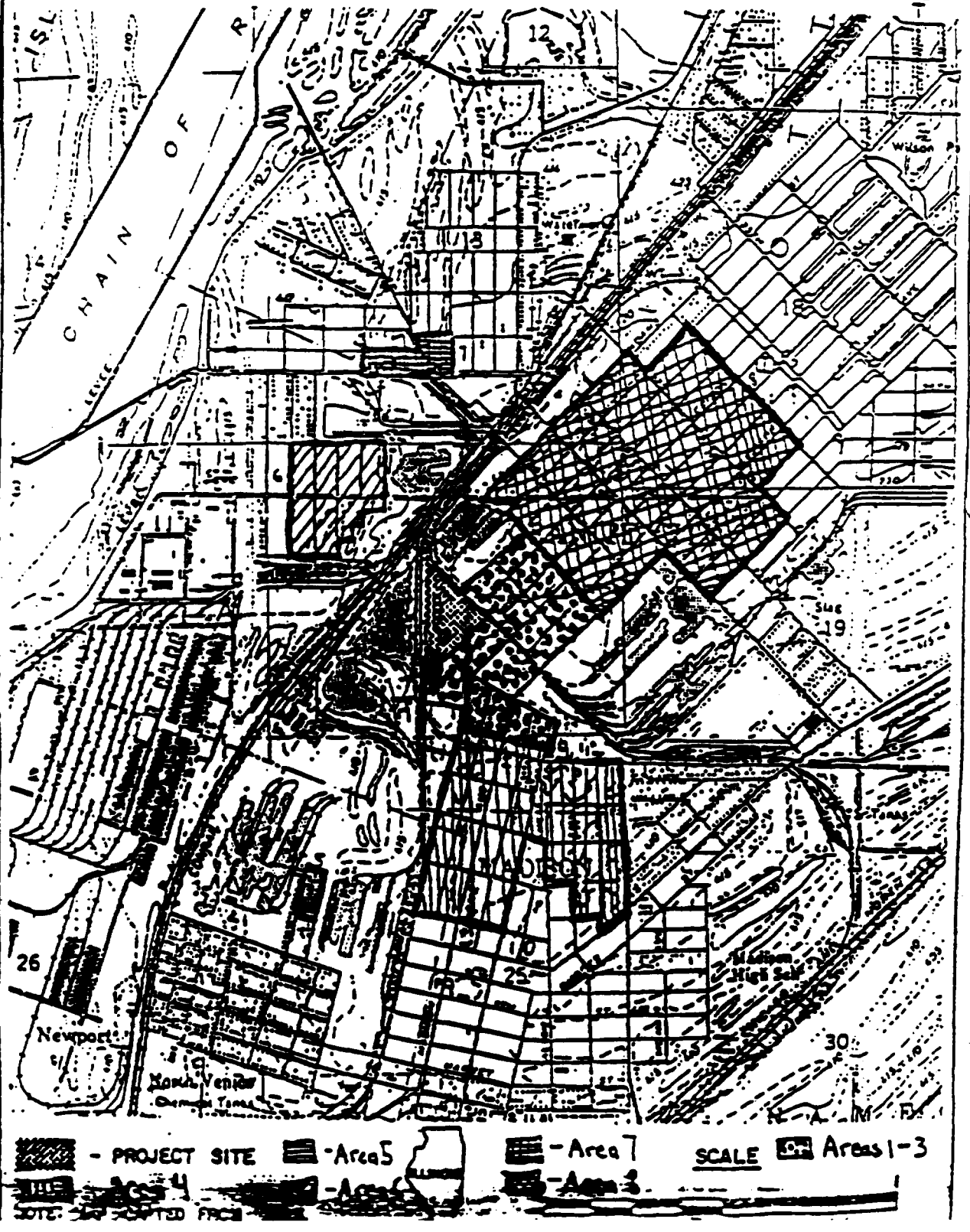


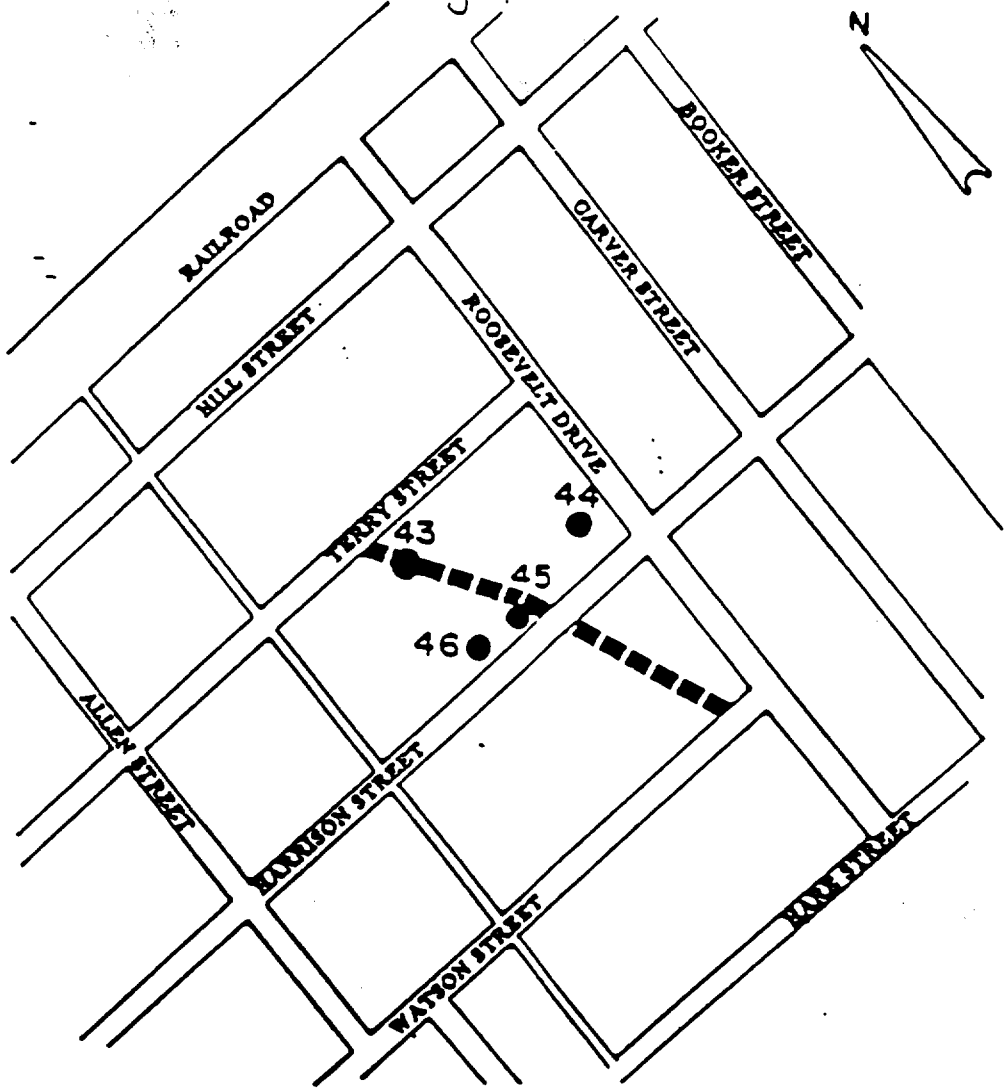
Figure 2

NL INDUSTRIES
GRANITE CITY SITE
GRANITE CITY, ILLINOIS
Estimated Areas of Lead Contamination
Above 500 ppm



NOTE: MAP ADAPTED FROM

Figure 2
Estimated Areas of Contamination
Eagle Park Acres



REMOTE FILL AREA

EAGLE PARK ACRES

LEGEND

● SOIL SAMPLE LOCATION

APPROXIMATE LOCATION OF DITCH

SCALE

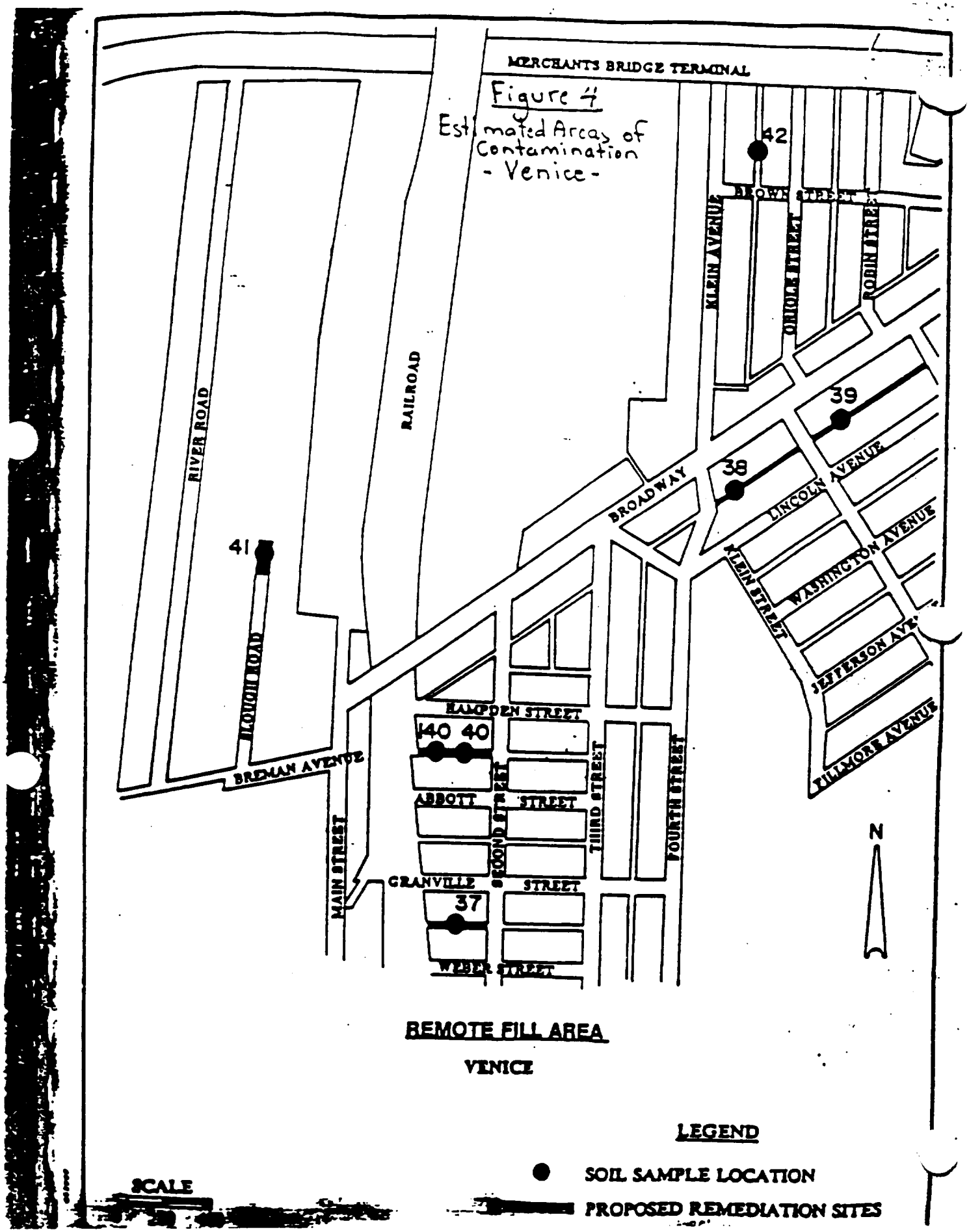
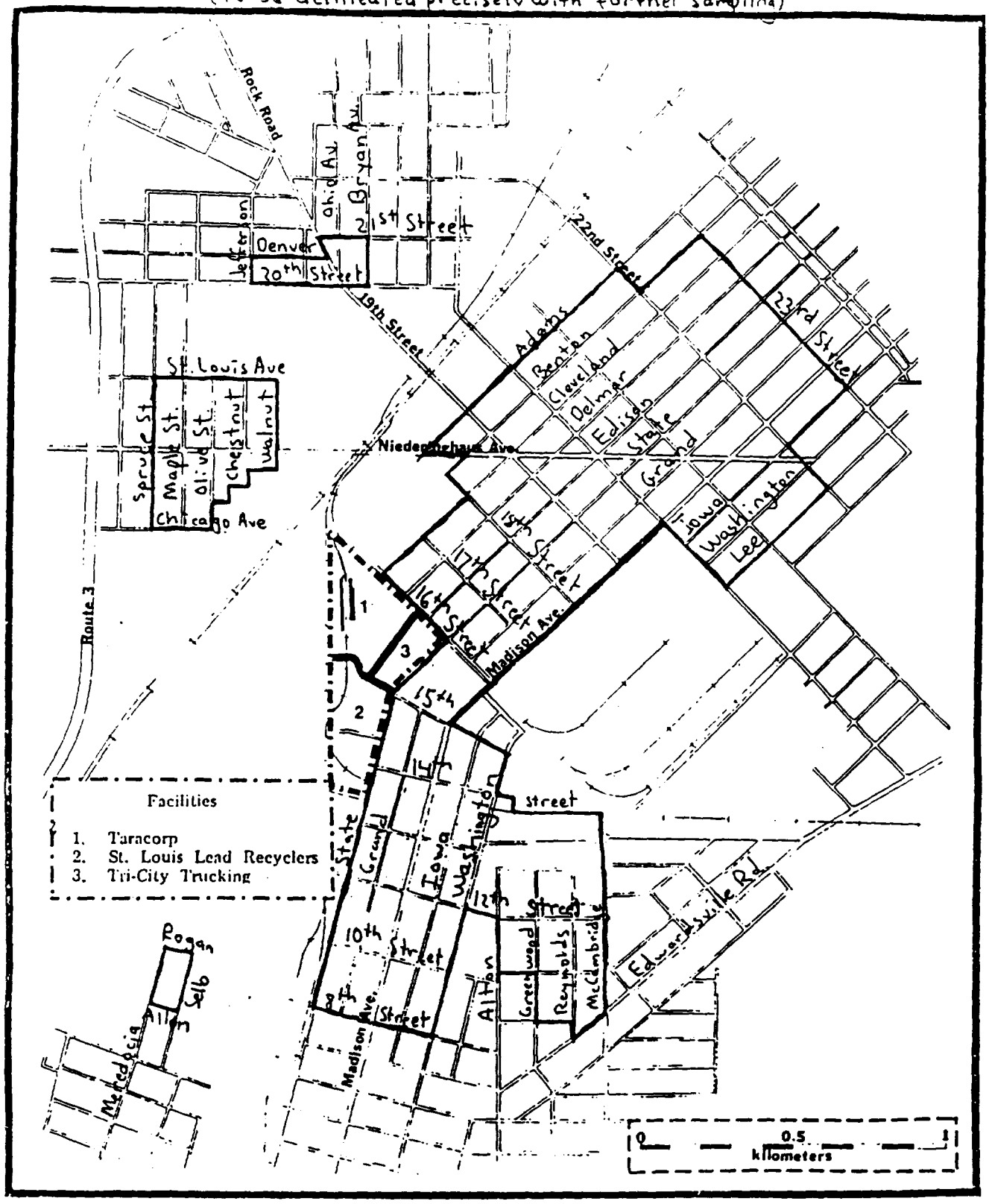


Figure 4
Estimated Areas of Contamination
- Venice -
MERCHANTS BRIDGE TERMINAL
42
BROWN STREET
KLEIN AVENUE
ORIOLE STREET
ROBIN STREET
39
38
LINCOLN AVENUE
WASHINGTON AVENUE
JEFFERSON AVE
FILLMORE AVENUE
KLEIN STREET
BROADWAY
RAILROAD
RIVER ROAD
41
ILLINOIS ROAD
BREMAN AVENUE
HAMPDEN STREET
140 40
ABBOTT STREET
MAIN STREET
SECOND STREET
THIRD STREET
FOURTH STREET
GRANVILLE STREET
37
WEBER STREET
N
REMOTE FILL AREA
VENICE
LEGEND
SOIL SAMPLE LOCATION
PROPOSED REMEDIATION SITES
SCALE

FIGURE 5

Estimated Areas Greater Than 500 ppm Lead

(To be delineated precisely with further sampling)



C.1

HEALTH AND SAFETY SCOPE OF WORK
(HTW SITE **REMEDIAL DESIGN** ACTIVITIES)

1. HEALTH AND SAFETY

a. General. The Architect Engineer (AE) contractor responsible for the tasks defined by this scope of work shall review all information provided and develop the necessary documents which contain the health and safety criteria, procedures, and practices sufficient to protect on-site personnel, the environment, and potential off-site receptors from the chemical, physical, and/or biological hazards particular to this site. The AE shall utilize the services of a Certified Industrial Hygienist (CIH) experienced in hazardous waste site operations and remediation to oversee the development and implementation of the health and safety documents required by this section. If the information made available is insufficient to allow the AE to develop these documents, a description of all additional information required shall be prepared and submitted to the Contracting Officer (CO).

b. Regulatory Requirements. All design activities and health and safety documents required by this scope of work shall comply with and reflect the following regulations and appropriate guidance publications, as a minimum:

(1) Federal Acquisition Regulation, F.A.R. Clause 52.236-13: Accident Prevention.

(2) U.S. Army Corps of Engineers (USACE), Safety and Health Requirements Manual, EM 385-1-1 (latest revision).

(3) Occupational Safety and Health Administration (OSHA), Construction Industry Standards, 29 CFR 1926, and General Industry Standards, 29 CFR 1910; especially 29 CFR 1910.120 - "Hazardous Waste Site Operations and Emergency Response".

(4) NIOSH/OSHA/USCG/EPA, "Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities", October 1985.

(5) Other applicable Federal, State, and local safety and health requirements.

c. Documents. The following health and safety documents are required to be developed under this scope of work. Avoid providing material of a general nature, not specifically related to this project or site. Information readily available in standard texts should be repeated only to the extent necessary to meet the requirements of this scope.

(1) Safety and Health Program. All contractors (AE and Construction) performing on-site activities at hazardous waste sites are required by regulation to develop and maintain a written Safety and Health Program in compliance with OSHA standard 29 CFR 1910.120 (b)(1) through (b)(4). Written certification that such a program has been prepared and implemented shall be submitted to the CO as a preface to required Site Safety and Health Plans (AE-SSHP and Construction SSHP). The Safety and Health Program shall be made available to the CO in its entirety upon request.

(2) Architect-Engineer Site Safety and Health Plan (AE-SSHP). If, in the course of conducting design activities pursuant to this scope of work, the AE and/or his subcontractors must perform on-site work, an Architect-Engineer Site Safety and Health Plan (AE-SSHP), as required by 29 CFR 1910.120 (b)(4), shall be prepared by the AE and submitted to the Contracting Officer for review and approval prior to the commencement of any such activity. The AE-SSHP shall describe the health and safety procedures, practices, and equipment to be implemented and utilized in order to protect affected personnel from the potential hazards associated with the site-specific tasks to be performed. The level of detail provided in the AE-SSHP shall be tailored to the type of work, complexity of operations to be accomplished, and hazards anticipated. All topics required by OSHA standard 1910.120 (b)(4), and those described in Paragraphs c.(3)(a) through c.(3)(p) below, shall be addressed in the AE-SSHP. Where the use of a specific topic is not applicable to the project, provide a negative declaration to establish that adequate consideration was given the topic, and give a brief justification for its omission.

(3) Health and Safety Design Analysis (HSDA). The AE shall prepare and include in the project design analysis a chapter which addresses the site-specific/hazard-specific health and safety considerations and protective measures to be instituted for the tasks/operations to be undertaken during subsequent remedial construction activities at the site. This chapter shall fully describe and justify the safety and health requirements to be specified in the remedial action contract, including the decision logic used in their selection. The HSDA shall include

the elements outlined below, as a minimum:

(a) Site Description and Contamination Characterization. Describe the site location, topography, approximate size of the site, the onsite jobs/tasks to be performed, and the duration of planned site activities. Compile a complete list of the contaminants found or known to be present in site areas to be impacted by the work to be performed. Compilation of this listing shall be based on results of previous studies; or if not available, select the likely contaminants based on site history and prior site uses/activities. Include chemical names, concentration ranges, media in which found, locations on-site, and estimated quantities/volumes to be impacted by site work.

(b) Hazard/Risk Analysis. Identify the chemical, physical, biological, and safety hazards of concern for each site task and/or operation to be performed. Selection of chemicals as indicators of hazard shall be based on media concentrations, toxicity, volatility or potential for air entrainment at hazardous levels, and frequency of detection. Describe chemical and physical properties of selected contaminants, sources and pathways of employee exposures, anticipated on and off-site exposure level potentials, and regulatory (including Federal, State, and local) or recommended protective exposure standards. Specify and justify "action levels" based upon airborne exposure hazards and direct skin contact potentials for upgrades/downgrades in levels personnel protection; for implementation of engineering and/or work practice controls; for emergency evacuation of on-site personnel; and for the prevention and/or minimization of public exposures to hazards created by site activities. Air monitoring/sampling shall be performed in accordance with Paragraph c.(3)(h) below, resulting data compared with established "action levels", and appropriate corrective actions initiated as necessary.

(c) Accident Prevention. The SSHP (AE and Construction) will serve as the Accident Prevention Plan (APP) and activity hazard analyses (phase plans), required by F.A.R. Clause 52.236-13, and Paragraphs 01.A.03 through 01.A.06 and Appendix Y of USACE EM 385-1-1. Thus a separate APP is not necessary. Any additional topics required by EM 385-1-1, but not specifically covered in Paragraphs c.(3)(a) through c.(3)(p) of this scope of work, shall be addressed in the Accident Prevention section. Daily safety and health inspections shall be conducted to determine if operations are being performed in accordance with the SSHP, USACE and OSHA regulations, and contract requirements. In the event of an accident/ incident, the contractor shall immediately notify the CO. Within two (2) working days of any reportable accident, the contractor shall complete and submit to the CO an Accident Report on ENG Form 3394 in accordance with AR 385-40 and USACE Supplements to that

regulation.

(d) Staff Organization, Qualifications, and Responsibilities. Discuss the organizational structure, including lines of authority (chain of command), and overall responsibilities of the contractor and all subcontractors for site activities, including supervisor/employee relationships. Summarize the operational and health and safety responsibilities and qualifications of each key person identified. Specifically: (1) A Certified Industrial Hygienist (CIH) with experience in hazardous waste site operations shall be responsible for the development, implementation, and oversight of the Safety and Health Program and Site Safety and Health Plans (SSHP). All SSHP shall be signed and dated by the CIH prior to submittal. (2) A fully trained and experienced Site Safety and Health Officer (SSHO), responsible to the contractor and the CIH, may be delegated to implement and continually enforce the safety and health program and site-specific plan elements on-site. (3) At least one person certified in first aid/CPR by the Red Cross, or equivalent agency, shall be present on-site at all times during site operations.

(e) Training. All personnel performing on-site activities shall have completed applicable training in accordance and compliance with 29 CFR 1910.120(e). In addition, site-specific training covering site hazards, procedures, and all contents of the approved SSHP shall be conducted by the SSHO for on-site employees and visitors prior to commencement of work or entering the site. The type (including initial, supervisory, refresher, and site-specific), duration, and dates of all employee training performed shall be listed by employee name and certified in the SSHP.

(f) Personal Protective Equipment (PPE). A written Personal Protective Equipment (PPE) program in accordance with 29 CFR 1910.120 (g)(5) and 29 CFR 1910.134 is required. Describe in detail the minimum PPE ensembles (including respirators) and specific materials from which the PPE components are constructed for each site-specific task/operation to be performed, based upon the hazard/risk analysis performed above. Components of levels of protection (A,B,C,D and modifications) must be relevant to site-specific conditions, including heat stress potential and safety hazards. Include site-specific procedures for on-site fit-testing, cleaning, maintenance, inspection, storage, determinations of program effectiveness and upgrade/downgrade criteria.

(g) Medical Surveillance. All personnel performing on-site activities shall be participants in an ongoing medical surveillance program, meeting the requirements of 29 CFR 1910.120 and ANSI Z-88.2. All medical surveillance protocols

and examination results shall be reviewed by a licensed physician who is certified in Occupational Medicine by the American Board of Preventative Medicine, or who, by necessary training and experience, is Board-eligible. In consultation with such an occupational physician, the AE shall specify the minimum content and frequencies of necessary medical tests/examinations/consultations based upon probable site conditions, potential occupational exposures and required protective equipment to be utilized. Certification of participation in the medical surveillance program, the date of last examination, and name of reviewing occupational physician shall also be included for each affected employee. The written medical opinion from the attending physician required by 29 CFR 1910.120(f)(7) shall be made available upon request to the CO for any site employee.

(h) Exposure Monitoring/Air Sampling Program. (Personal and Environmental). Where it has been determined that there may be employee exposures to and/or off-site migration potentials of hazardous airborne concentrations of hazardous substances, appropriate direct-reading (real-time) air monitoring and integrated (time-weighted average (TWA)) air sampling shall be conducted in accordance with applicable regulations (OSHA, EPA, State). Both air monitoring and air sampling must accurately represent concentrations of air contaminants encountered on and leaving the site. Sampling and analytical methods following NIOSH (for on-site personnel and site perimeter locations) and/or EPA (for site perimeter or off-site locations) criteria shall be appropriately utilized. Personnel samples shall be analyzed only by laboratories successfully participating in and meeting the requirements of the American Industrial Hygiene Association's (AIHA) Proficiency Analytical Testing (PAT) or Laboratory Accreditation programs. Meteorological monitoring shall be performed on-site as needed and used as an adjunct in determining perimeter and any off-site monitoring/sampling locations. Where perimeter monitoring/sampling is not deemed necessary, provide a suitable justification for its exclusion. Noise monitoring and radiation monitoring (alpha, beta, gamma) shall be conducted as needed, depending on the site hazard assessment. All monitoring/sampling results shall be compared to "action levels" established pursuant to Paragraph c.(3)(b) above to determine acceptability and need for corrective action.

Environmental monitor will not be used in this project.

(i) Heat/Cold Stress Monitoring. Heat and/or cold stress monitoring protocols shall be specified and implemented, as appropriate. Work/rest schedules shall be determined based upon ambient temperature, humidity, wind speed (wind chill), solar radiation intensity, duration and intensity of work, and protective equipment ensembles. Minimum required physiological monitoring protocols which will affect work schedules shall be developed. In cases where impervious

clothing is worn (full-body), the NIOSH/OSHA/USCG/EPA "Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities" protocol for prevention of heat stress shall be followed, and heat stress monitoring shall commence at temperatures of 70 degrees Fahrenheit and above. Where impervious clothing is not worn, the most current published ACGIH heat stress standard (TLV) shall be used. For cold stress monitoring to help prevent frostbite and hypothermia, the most current published ACGIH cold stress standard shall be referenced and followed, as a minimum.

(j) Standard Operating Safety Procedures, Engineering Controls and Work Practices. Address the following elements as a minimum and appropriate: (1) Site rules/ prohibitions (buddy system, eat/drink/smoking restrictions, etc.); (2) Material handling procedures (soils, liquids, radioactive materials); (3) Drum/container handling procedures and precautions (opening, sampling, overpacking); (4) Confined space entry procedures; (5) Hot-work, sources of ignition, and electrical safety (ground-fault protection, overhead power line avoidance, etc.); (6) Excavation safety; (7) Machine guarding; (8) Fall protection; (9) Illumination; (10) Sanitation; (11) Engineering controls; and (12) Transport and Disposal of waste..

(k) Site Control Measures. Include a site map, work zone delineation and access points. Describe on-site and off-site communications, security (physical and procedural), and general site access.

(l) Personal Hygiene and Decontamination. Specify necessary facilities and their locations. Detail standard operating procedures, frequencies, supplies and materials to accomplish decontamination of site personnel.

(m) Equipment Decontamination. Specify necessary facilities, equipment, and their locations. Detail procedures, frequencies, supplies and materials, and methods to determine adequacy for the decontamination of equipment used on-site

(n) Emergency Equipment and First Aid Requirements. The following items, as a minimum (as appropriate), shall be immediately available for on-site use: (1) First aid equipment and supplies approved by the consulting MD; (2) Emergency eyewashes/showers (ANSI Z-358.1); (3) Emergency-use respirators (worst-case appropriate); (4) Spill control materials and equipment; (5) Fire extinguishers (specify type, size, locations).

(o) Emergency Response and Contingency Procedures (On-Site and Off-Site). The AE shall contact local fire/police/rescue authorities having jurisidiction and nearby

medical facilities that would be utilized for emergency treatment of injured personnel in order to notify them of upcoming site activities and potential emergency situations; to ascertain their response capabilities; and to obtain a response commitment. An Emergency Response Plan, which complies with 29 CFR 1910.120 (l), shall be developed and implemented which addresses the following elements, as a minimum: (1) Pre-emergency planning and procedures for reporting incidents to appropriate government agencies for potential chemical exposures, personal injuries, fires/explosions, environmental spills and releases, discovery of radioactive materials; (2) Personnel roles, lines of authority, communications; (3) Posted instructions and list of emergency contacts: physician/nearby medical facility, fire and police departments, ambulance service, state/local/federal environmental agencies, CIH, Contracting Officer; (4) Emergency recognition and prevention; (5) Site topography, layout, and prevailing weather conditions; (6) Criteria and procedures for site evacuation (emergency alerting procedures/employee alarm system, emergency PPE and equipment, safe distances, places of refuge, evacuation routes, site security and control); (7) Specific procedures for decontamination and medical treatment of injured personnel; (8) Route maps to nearest pre-notified medical facility; (9) Criteria for initiating community alert program, contacts, and responsibilities; and (10) Critique of emergency responses and follow-up.

(p) Logs, Reports, and Recordkeeping. The following logs, reports, and records shall be developed, maintained, and submitted to the CO at the conclusion of the site work: (1) Training logs (site-specific, visitor); (2) Daily safety inspection logs (may be part of the Daily QC Reports); (3) Employee/visitor register; (4) Environmental and personal exposure monitoring/sampling results.

(q) Revisions and Addenda. Review comments issued prior to SSHP approval shall be incorporated by revising and reissuing affected pages. If major revisions are necessary, the entire Plan shall be resubmitted. Minor changes affecting only a few pages may be made by addenda sheet.

(r) Field Modifications. Unanticipated field conditions will occasionally require field modifications of the SSHP. Any PPE upgrade two working levels higher than the assumed working level discussed in the SSHP for the task involved will require notification of the COR prior to conduct of the activity. Any immediately dangerous to life and health (as defined by NIOSH), confined space entry, or physical hazard the result of which if the employee under reasonable circumstances considered exposed, would lead to possible death or permanent injury, shall also require prior notification of the

activity if not specifically covered in the SSHP. Any PPE upgrades of one level will be reported on the Daily Safety Inspection Log. Minor changes not affecting the degree of protection need not be reported.

During site activities, if employee air contaminant exposures exceed OSHA-PELs, ACGIH-TLVs, or SSHP respiratory upgrade levels, or if any employee suffers a work related lost workday accident as defined by OSHA, or the event is covered in ER 385-1-1 Section 02.A.04, the Omaha District Environmental Branch shall be notified within 24 hours of the event. Within two (2) working days of any reportable accident, the contractor shall submit sufficient information to allow completion of ENG Form 3394 in accordance with AR 385-40 and USACE Supplement 1 to that regulation.

(4) Safety, Health, and Emergency Response Specifications. The AE shall prepare a section of the remedial action contract specifications which describes the minimum safety, health, and emergency response requirements to which the construction/remedial action contractor shall adhere. These specifications shall require that the contractor develop and implement his own Site Safety and Health Plan (Construction-SSHP). The contract requirements shall be fully developed from the Health and Safety Design Analysis (HSDA) and shall be described in a specification section entitled: "Safety, Health, and Emergency Response". All minimum site-specific, task-specific, and hazard-specific procedures, precautions, and equipment as determined necessary and described in the HSDA shall be reflected as clearly biddable and enforceable contractual requirements in this section of the specifications. In addition, the Site Description and Contamination Characterization portion of the HSDA shall be incorporated for information as an appendix to this specification section.

d. CO-Approved Visitors. All USACE contractors (AE and Construction) shall continuously maintain on-site a minimum of four (4) sets of protective equipment (except for air-purifying respirators, prescription safety glasses, and safety shoes) for government visitor usage. These ensembles shall include all PPE specified in the SSHP.

10.2

Chemistry Input for
Scope of Services
NL Industries/Taracorp Site,
Granite City, Illinois

Analytical Plan.

1. General. Sampling activities and chemical analysis for the investigation of NL Industries/Taracorp Site must follow appropriate procedures necessary to obtain defensible data. The following sections refer to the acquisition of good quality data generally found in ER-1110-1-263, October 1, 1990. These sections have been revised where necessary and included here for emphasis. All procedures and activities performed in the acquisition of these data as described below must be included in the Chemical Data Acquisition Plan (CDAP) for approval.

2. Chemical Data Acquisition Elements in the CDAP.

2.1 Definition and Responsibility. Chemical data acquisition (CDA) consists of all field activities, laboratory activities, and contract deliverables related to the acquisition and reporting of chemical data for HTW investigation or remedial activities, which would include applicable activities at the NL Industries/Taracorp site.

Chemical Data Acquisition as described in the CDAP must be approved by the CO prior to initiation of field work. In the event corrections and comments on the draft are provided by the CO, the changes, documented by written annotated comments shall be incorporated by the authors in a revised plan before final approval is given. It should be noted that the purpose and content of the CDAP are the same as the QAPP required for Superfund investigations by the EPA. Additional requirements by the State of Illinois shall also be addressed.

2.2 USACE Chemical Quality Data Management. USACE requires that Quality Control (QC) and Quality Assurance (QA) samples be collected and analyzed by the contract laboratory and the USACE QA laboratory, respectively. These QC and QA samples include splits or replicates of field samples. QC samples help the contractor and contract laboratory to identify and diagnose problems related to sampling and analysis.

2.2.1 QA Samples. QA samples are sent to a USACE QA laboratory by overnight delivery for government monitoring of sampling and contract laboratory performance. The Government (USACE) QA laboratory designated for this project is:

U.S. Army Corps of Engineers
Missouri River Division (MRD) Laboratory
ATTN: CEMRD-ED-L (Sample Custodian)
420 South 18th Street
Omaha, NE 68102
Telephone: (402) 444-4314

2.2.2 MRD Project Identification for QA Samples. THe A-E shall be responsible for adding the Project ID "MRD LIMS 1019" to the labels and chain-of-custody records for all QA samples shipped to the MRD Laboratory.

2.2.3 QC Laboratory Turnaround Time. The A-E shall provide a maximum turnaround time of 25 days (from receipt of samples) on all laboratory analyses of QC samples.

2.2.4 The number of QA/QC samples to be taken shall be detailed in the CDAP under a section entitled "Chemical Data Quality Objectives."

2.2.5 When the following procedures, performed by the USACE QA laboratory, demonstrate that chemical quality control contract requirements were not met, samples may be reanalyzed and/or re-collected at the expense of the A-E:

2.2.5.1 Inspection of QA samples to insure that sampling procedures correspond to Chemical Data Acquisition with regard to sample containers, preservation, labeling, chain of custody, etc.

2.2.5.2 Analyses of QA samples.

2.2.5.3 Evaluation of contractor deliverables specified for the acquisition of data.

2.2.5.4 Comparison of analytical results obtained by A-E/contract laboratory and USACE QA laboratory from split or replicate samples.

2.2.6 The procedures for obtaining QA laboratory services are in Appendix C to ER 1110-1-263.

2.3 Contract Laboratory Validation. Any laboratory performing chemical analyses shall be validated by USACE Missouri River Division (MRD). Laboratories are validated for each environmental matrix and each specific analytical method to be employed. If the prime contractor selects a laboratory which has a current (within 1 year) validation for all analytes and matrices specific to its project, additional evaluation will not be necessary. If the prime contractor selects a laboratory which does not have a current validation, the laboratory shall be validated prior to approval of the CDAP. Commercial laboratory validation procedures are in Appendix C to ER 1110-1-263. Samples may not be subcontracted to another laboratory without the approval of CEMRD and unless the second laboratory is validated for the parameters concerned.

2.4 Chemical data acquisition elements of the CDAP include the following as a minimium:

2.4.1 Title Page. At the bottom of the title page, provisions must be made for the signatures of approving personnel. As a minimum, the CDAP must be approved by the following:

2.4.1.1 QA Staff Person
2.4.1.2 QA Supervisor
2.4.1.3 EPA Remedial Project Manager (Brad Bradley)
2.4.1.4 Illinois EPA

2.4.2 Table of Contents. The CDAP shall address each of the following items:

2.4.2.1 Introduction.
2.4.2.2 A serial listing of each of the CDAP components.
2.4.2.3 A listing of any appendices which are required to augment the CDAP as presented (i.e., standard operating procedures, etc.). At the end of the Table of Contents, list the QAO (Quality Assurance Officer) and all other individuals receiving official copies of the CDAP and any subsequent revisions.

2.4.3 Project Description. This section shall include a description of the work site and any unusual conditions. Anticipated project start and completion dates shall be estimated. This section shall also provide a summary of past and future work at the site including past multimedia chemical data of significance as well as a presentation of the multimedia sampling to be carried out in the present work effort. It is the intent at the NL Industries/Taracorp Site to implement the Record of Decision (ROD) for this Site which was signed by the Regional Administrator on March 30, 1990.

2.4.4 Contractor Project Organization and Functional Area Responsibilities. The project organization for the prime contractor and any subcontractors shall be clearly defined with a discussion of quality control responsibilities. The prime contractor's Quality Assurance (QA) Officer shall report to a responsible senior officer of the company (i.e., QA management shall be separate from project management). A list of all individuals shall be provided and will include QC officers for the various components (those responsible for initiating and carrying out corrective actions and those involved in the data reporting sequence) and all analytical laboratory personnel (supervisors, chemists, and technicians). Resumes of all non-laboratory AE/Contractor personnel listing education and experience are required, including personnel collecting samples. List the names of field personnel that will wear monitoring equipment. For laboratory personnel that are not included in the Lab Quality Management Plan, resumes listing education and experience are required.

2.4.5 Chemical Data Quality Objectives. This section shall include a description of the general scope of work and relevant background information as it relates to the acquisition of chemical analytical data. State the objectives of the project: what questions must be answered and what decisions must be made. Describe the level and extent of chemical data required to answer

questions and support decisions during the project: the approach for sample collection, sample analysis, and QA/QC which will result in the required chemical data.

2.4.6 Field Activities. Briefly summarize types of field activities required by the project.

2.4.7 List of Equipment, Containers, and Supplies to be taken to the Field. This section shall include all sample screening equipment to be used (brand, model, serial number) and a description of its calibration as well as sampling equipment, decontamination supplies and sample containers (specific numbers and types).

2.4.8 Sampling Locations. This section shall provide the location of each sampling point on a site map. These locations shall be identified by the Contractor after a visual inspection if they are not already specified. The rationale for the sampling location and frequency (including QA/QC) shall be addressed in the Section Data Quality Objectives.

2.4.9 Sampling and Preservation Procedures. The CDAP shall include a table, which lists sampling locations, matrix (waste, soil, water, etc.), number of field samples, number of split or replicate samples, and number of rinsate or trip blank samples. Specific sampling, preservation, etc. details shall be included. All details shall meet the requirements of one of the following: (a) EPA SW-846 method; (b) another EPA method; (c) ASTM method; (d) NIOSH method (for air sampling); or (e) another accepted published method. Container and preservation specifications shall meet all appropriate requirements. (see Appendix F to ER 1110-1-263). Each table entry shall include the reference, if any, from which the specifications were taken. Any modifications to the standard methods must be approved by the CO with the concurrence of the QA laboratory prior to their use. All methods should be referenced to the most recent edition of their source. If a standard method is not available, the AE/Contractor or subcontractors shall propose a nonstandard method with validation data for approval by the CO.

2.4.10 Details of Sampling and Preservation Procedures. The composition and volume of sample containers shall be specified along with a description of their preparation and cleaning. Sampling equipment directly contacting the sample shall be stainless steel or Teflon. The CDAP shall describe the cleaning of equipment and precautions for prevention of sample cross contamination during collection. Any field screening methods employed to select samples for analyses shall be discussed in detail. Compositing and homogenizing procedures shall be included where appropriate. Sample containers, volumes, preservatives and holding times for the common analyses in low concentration are presented in Table 1. A more detailed table is presented in Table E-1 of the Sample Handling Protocol (Appendix F).

2.4.10.1 Soil Sampling Procedure. Using stainless steel or Teflon sampling equipment enough solid is removed from a specified depth to fill the required containers. The volatile organic samples should be removed first with as little mixing as possible. The remaining soil shall be placed in a clean stainless steel bowl and mixed thoroughly with stainless steel implements (spoons, spades, etc.), then divided among the sample containers to be filled and properly preserved. QC and/or QA sample containers shall be filled from the same mixture as one of the samples. If other methodologies are warranted as specified by the Data Quality Objectives they must also be clearly defined in the CDAP.

2.4.10.2 Other Matrices. Sampling methods and equipment used shall meet the requirements of EPA or NIOSH methods.

2.4.11 Field Documentation. The system for identifying and tracking the samples shall be described, and shall include the recording of field data in permanently bound notebooks along with the method of relating the field data to the proper samples. All field documentation shall be done in indelible ink. Daily Quality Control Reports shall be prepared daily, dated, signed by the site manager, and sent to the CO at a rate approved by the CO. These reports shall include (with respect to chemistry) weather information at the time of sampling, samples taken with reference given to appropriate sections of the CDAP, field instrument measurements and calibrations. Any deviations from the CDAP shall be stated. All field documentation will become part of the project files.

2.4.12 Sample Chain of Custody and Transportation. All sample labeling, packing, transportation and chain of custody procedures shall follow the USACE Sample Handling Protocol (Appendix F to ER 1110-1-263).

2.4.13 Laboratory Analytical Procedures. Specific laboratory procedural details shall be included. Each method shall be specified exactly and in detail by one of the following: (a) reference to an EPA SW-846 method; (b) reference to another EPA method; (c) reference to an ASTM method; (d) reference to a NIOSH method (for air analysis); (e) reference to another accepted published method; (f) reference to an accepted published method with a description of any deviations from the published procedure; or (g) complete description of the procedure, e.g., copies of laboratory instructions. EPA SW-846 methods shall be used where possible. Generally, nonstandard methods are not allowed. In special cases that require the consideration of nonstandard methods, the contract laboratory shall be prepared to provide validation data. The use of proposed nonstandard methods requires prior approval of the CO. A list of sample preparation and analytical methods most frequently used is presented in Table D-2 (ER-1110-1-263). A table shall be included which lists for each matrix sample preparation method number, analytical method number, analytes and laboratory quantitation limits.

2.4.14 Preventive Maintenance. The instrument, including manufacturer, model, accessories, etc., shall be specified and preventive maintenance shall be described. Preventive maintenance shall be performed by qualified personnel. Records of repairs, adjustments and calibrations shall be maintained and available for inspection by the CO on request. This includes any field instrumentation.

2.4.15 Instrument Calibration and Frequency. Description of the procedure used for calibration and frequency of checks is required for each instrument or method including field instruments. These shall be consistent with the requirements of the contract and the analytical method.

2.4.16 Analytical Methods. Include the required concentration range and data on the sensitivity (detection limits), precision, and accuracy. Indicate how pre-existing data on sensitivity, precision, and accuracy were determined, and procedures to be used to validate the method. State source and purity of analytical reference materials and laboratory chemicals necessary to perform the analyses. Nominal detection limits for common analytes are given Appendix D Tables D-3 through D-6 of the ER-1110-1-263. DQO's for specific projects will affect the value of required detection limits and goals for precision, accuracy, and completeness.

2.4.17 Method Specific Data Quality Objectives. Provide objectives for precision, accuracy, detection limits, and completeness. DQO's for accuracy and precision established for each measurement parameter will be based on prior knowledge of the specific measurement system used and method validation studies employing replicate analyses, spikes, standards, calibrations, recoveries, control charts and project specific requirements. Completeness refers to the amount of valid data obtainable (by the specific method in the laboratory used with the instrument to be employed) from a measurement system compared to the expected amount of data, and is usually expressed as a percentage.

2.4.18 Quality Control Checks. Quality control checks are necessary to evaluate performance reliability for each measurement parameter. Describe procedures to assess the precision, accuracy and completeness of the measurement. The numbers and types of internal laboratory QC checks and samples proposed (e.g., blanks, duplicates, splits, spikes, surrogates, and reference standards, as applicable) shall be defined clearly. At a minimum these must be run at the rates prescribed in the individual methods. The laboratory's established practice for including control samples among the samples analyzed, and any additional controls required by the present project, shall be described. Describe the feedback systems used to identify problems by means of the results obtained from control samples. Limits of data acceptability shall be included. Results from laboratory internal quality control checks shall be reported with the

analytical data. Standard forms should be used, preferably CLP or SW-846 recommended format.

2.4.19 Corrective Action. Plans for corrective actions to be taken when results appear unusual, questionable, or limits of acceptability are exceeded shall be included. When limits of acceptability are exceeded, information justifying the poor recovery or precision shall be documented. When QA/QC problems are identified, the A-E shall notify the USACE-PM as soon as possible. This notification will normally be expected to occur within 48 hours. Describe how reestablishment of control is demonstrated.

2.4.20 Data Reduction, Validation, and Documentation. Equations, including units, required to calculate the concentration or value of the measured parameter, shall be included. Describe the data management systems which collect raw data, store data, and document quality control data. If statistical procedures are used for data review before reporting, include descriptions. Data validation procedures and organization shall be specified. The contract laboratory or the prime contractor hold and make available all project raw data for a period of two years after samples have been analyzed.

2.4.21 Chemical Data Quality Control Deliverables. The contractor shall address the frequency and content of chemical data quality control reports that shall be submitted during the project.

2.4.21.1 A-E Daily Quality Control Report (A-E DQCR). During the field investigation activities, the A-E shall provide Daily Quality Control Reports (DQCRs) to the Government. These reports shall be compiled and sent to the USACE-PM once every week in the event that no problems or deviations from the schedule arise. However, should problems arise the A-E shall notify the USACE-PM immediately and send the A-E DQCRs by telefax or express mail on a daily basis until the problem has been corrected. These reports shall include, but shall not be limited to, the minimum information listed in ER 1110-1-263 plus information addressing the following list of topics:

2.4.21.1.1 Date (and corresponding sequential report number);

2.4.21.1.2 Location of the work (including installation, site, boring, etc.);

2.4.21.1.3 Weather information (including temperature, wind speed and direction, humidity, precipitation, etc.);

2.4.21.1.4 Work performed;

2.4.21.1.5 Sampling performed (including specifics such as location, type of samples, log number, etc.);

2.4.21.1.6 Field analysis performed (including results, instrument checks and calibration, problems, etc.);

2.4.21.1.7 Problems encountered and corrective actions taken (including specifics regarding sampling problems and alternate sampling methods utilized);

2.4.21.1.8 Quality control activities;

2.4.21.1.9 Verbal or written instructions from government personnel;

2.4.21.1.10 Types of tests performed, samples collected, personnel involved, etc.;

2.4.21.1.11 Calibration procedures and recording;

2.4.21.1.12 Names of all personnel on-site (including their corporate, government, or other affiliations, their job titles, and their job functions and/or reasons for being on-site);

2.4.21.1.13 Equipment used;

2.4.21.1.14 Health and Safety considerations (including site control measures, levels of personal protection required, on-site monitoring activities and results, accidents, etc.);

2.4.21.1.15 Deviations from approved workplan;

2.4.21.1.16 General and specific remarks;

2.4.21.1.17 Expected activities for the next working day;

2.4.21.1.18 Distribution list for the DQCRs;

2.4.21.1.19 Signature and job title of the DQCR's preparer;

2.4.21.1.20 Drill logs

2.4.21.2 Daily Quality Control Report from the contract laboratory as appropriate.

2.4.21.3 Non-routine Occurrences. Include problems identified, corrective actions, and verbal/written instructions from USACE personnel for sampling or re-analysis. These reports of significant problems should be sent to the CO within 48 hours of the occurrence.

2.4.21.4 Data Report to the QA Laboratory. The contractor's data must be submitted to the designated quality assurance laboratory for data validation and comparison purposes as soon as it is available. This submittal should include all sample, blank and internal quality control results such as spike and surrogate recoveries and agreement between replicate analyses. Interim data reports may be requested if the project warrants. The following are minimum data reporting requirements:

2.4.21.4.1 Sample IDs. The contractor shall prepare a tabular presentation which matches contract laboratory sample IDs to QA laboratory sample IDs. This table shall identify all Field Duplicates and Field Blanks as such and match with their corresponding field samples where applicable.

2.4.21.4.2 Sample Receipt. The contractor shall complete and report a "Cooler Receipt Form" for all shipments for purposes of noting problems in sample packaging, chain-of-custody, and sample preservation. An example form is available from the Missouri River Division Laboratory.

2.4.21.4.3 General Organic And Inorganic Reporting. For each analytical method run, the contractor shall report all analytes for each sample as a detected concentration or as less than the specific limits of quantitation. Generally, all samples with out-of-control spike recoveries being blamed on matrix interferences shall be designated as such. All soil samples shall be reported on a dry-weight basis with percent moisture also reported unless otherwise approved. The contractor shall also report dilution factors for each sample as well as the date of extraction (if applicable) and date of analysis.

2.4.21.4.4 Internal Quality Control Reporting at a minimum, internal quality control samples shall be analyzed at rates specified in the specific methods or higher rates if required to meet project specific Data Quality Objectives:

2.4.21.4.4.1 Laboratory Blanks (Method Blanks and Instrument Blanks). All analytes shall be reported for each laboratory blank. All non-blank sample results shall be designated as corresponding to a particular laboratory blank in term of analytical batch processing.

2.4.21.4.4.2 Surrogate Spike Samples. Surrogate Spike Recoveries shall be reported with all organic method reports where appropriate (i.e. when the method requires surrogate spikes). The report shall also specify the control limits for surrogate spike results as well as the spiking concentration. Any out-of-control recoveries as defined in the specified method shall result in the sample being rerun (both sets of data are to be reported) at no additional cost to the government.

2.4.21.4.4.3 Matrix Spike Samples. Matrix Spike Recoveries shall be reported for all organic and inorganic analyses. All general sample results shall be designated as corresponding to a particular matrix spike sample. The report shall indicate what field sample was spiked even if it was not a Corps of Engineers project sample. The report shall also specify the control limits for matrix spike results for each method for each matrix.

2.4.21.4.4.4 Laboratory Duplicates and/or Matrix Spike Duplicate Pairs. Relative Percent Difference shall be reported for all duplicate pairs as well as analyte/matrix specific control limits.

2.5 Quality Control Summary Report (QCSR). This document addresses quality control practices employed and summarizes the DQCR. Issues covered in this report shall include a discussion of all data points which may have been influenced or compromised and their impact on the Data Quality Objectives or remedial decisions. An example of the elements required for this level of effort are presented below, but are not limited to the following items:

2.5.1 Project Description - Elements of this include report organization and site description.

2.5.2 Laboratory Quality Control Activities - Elements are a summary of planned laboratory quality control activities, a summary of any deviations from planned activities, and a summary of the evaluation of the data quality for each analysis and matrix.

2.5.3 Field Quality Control Activities - Elements are a summary of planned field quality control activities, a summary of any deviations from planned activities, and a summary of the evaluation of the quality of the sampling.

2.5.4 Data Presentation and Evaluation - Elements are an assessment of sampling and analysis techniques, an evaluation of the data quality of each matrix and parameter, and an evaluation of the usability of the data.

2.5.5 Lessons Learned - A summary of field or analytical procedures that could be changed or modified to better characterize chemical contamination in future work efforts.

2.5.6 DQCR Consolidation - Daily Quality Control Reports are to be consolidated and summarized.

3. Analytical Requirements. The following matrix-specific analytical methods are recommended for the soil and groundwater samples taken. These methods along with appropriate digestion methods must be specified in the CDAP unless otherwise approved by the Corps of Engineers. These methods must be EPA-approved and consistent with any applicable current State of Illinois requirements as well as meeting specific Data Quality Objectives. The objectives and rationale and end data use for these methods must be clearly stated in the CDAP. These methods must explicitly follow all quality control procedures detailed in the respective methods unless otherwise authorized by the Corps of Engineers. Analytical and statistical control parameters are outlined in the section of this Scope of Services concerned with chemical data acquisition and must be consistent with the ER-1110-1-263, October 1, 1990.

3.1 Soil. Soil samples taken from the previously documented sites shall be analyzed by approved EPA methods as described in the current edition SW-846, unless otherwise indicated. These methods must be detailed as described above for the CDAP.

3.1.1 Lead shall be analyzed by Methods 3050/6010.

3.1.2 TCLP. Toxicity Characteristic Leaching Procedure analysis shall use extraction Method 1311. The TCLP leachate extracts for lead shall be analyzed by Method 6010.

3.2 Groundwater samples collected from the previously documented sites shall be analyzed by approved EPA methods as described in the current edition SW-846, unless otherwise

indicated. These methods must be detailed as described above for the CDAP.

3.2.1 Volatile organics shall be analyzed by 8240 using a capillary column (see Method 8260) for all compounds listed in Table 2 of this method unless otherwise approved. This analysis shall also include a ten peak library search for the tentative identification of compounds not on the above list for the landfill sites only. This method is recommended based upon its potential for positive identification.

3.2.2 Basic or neutral extraction of semivolatiles. The solvent extract obtained by performing either Method 3250 or 3520 at a neutral or basic pH will contain the compounds of interest. Refer to Table 1 in the extraction methods (3510 and/or 3520) for guidance on the pH requirements for extraction prior to analysis.

3.2.3 Acidic extraction of phenols and acids. The extract obtained by performing either Method 3510 or 3520 at pH 2 will contain the phenols and acid extractables.

3.2.4 Semi-volatile organics shall be prepared by methods 3510 or 3520 and analyzed by method 8270 for all compounds listed in Table 2 of this method unless otherwise approved by the CO. Appropriate extract cleanup methods shall also be performed where needed as specified in Section 7.2 of this method.

3.2.5 Organochlorine pesticides and PCBs shall be prepared by methods 3510 or 3520 and analyzed by method 8080 for 11 compounds listed in Table 1 of this method with second column confirmation.

3.2.6 TAL Metals shall be analyzed by Methods 3005/6010 for aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc. Arsenic, selenium, and lead shall be analyzed by the respective graphite furnace methods 7060, 7740, and 3020/7421 if not detected using Method 3020/6010. Mercury shall be analyzed by cold vapor Method 7471. Soil samples shall be calculated and reported on a dry weight basis.

NOTE: Any floating product or non-aqueous petroleum layer encountered must be sampled and shipped to the Corps of Engineers Missouri Division Laboratory in Omaha, Nebraska.

TABLE 1
SOIL SAMPLING SPECIFICATIONS

PARAMETER	CONTAINER[1]	SAMPLE[2] PRESERVATION	MAX HOLDING TIME[3] EXTRACT	ANALYSIS
Lead	1 x 8 oz wide mouth jar, G	Ice to 4°C	-	6 months

TABLE 2
GROUNDWATER/SURFACE WATER SAMPLING SPECIFICATIONS

PARAMETER	CONTAINER[1]	SAMPLE[2] PRESERVATION	MAX HOLDING TIME[3] EXTRACT	ANALYSIS
Volatile Organics	2 x 40 mL G, Septa vial no headspace	Ice to 4°C 4 drops conc HCl to pH<2	-	14 days < 24 hours on-site
B/N/A	2 x 1 L amber G	Ice to 4°C	7 days	40 days
PCBs/ Pesticides	2 x 1 L amber G	Ice to 4°C	7 days	40 days
TAL Metals	1 x 1 L P	Ice to 4°C HNO_3 to pH<2	-	6 months

[1] All containers must have Teflon-lined seals (Teflon-lined septa for all VOA vials). G = Glass; P = High density polyethylene.

[2] Sample preservation will be done in the field immediately upon sample collection. If samples are filtered in the field, differential pressure methods and 45 micron filters will be used. Preservation is added after filtration. VOA samples must never be filtered.

[3] When only one holding time is given, it implies total holding time from sampling until analysis.

10.3

Site Specific Chemistry

1. General. As part if the removal of lead contaminated soil at Area 1, all residential portions of Areas 2-8, Eagle Park Acres, Venice, Granite City, Madison, and other nearby communities, 5033 sampling locations will be completed by the Contractor. In addition to the 2518 sampling locations, four monitoring wells will be installed, one upgradient and three downgradient deep wells. All work is to be performed under the supervision of a Professional Engineer, a Professional Geologist, a Chemist and a Certified Industrial Hygienist. The Contractor shall refer to the Geology and Chemistry Appendices, also included in this Scope of Services, as guidance documents in planning for and carrying out the field tasks presented in this portion of the Scope. The Contractor is responsible for obtaining any permits or license and filing all reports required for this work. The Contractor may propose alternate locations and numbers of borings in the Chemical Data Acquisition Plan (CDAP). These shall be justified in the CDAP.

2. Area 1 - SLLR Pile.

2.1 Collection of Analytical Samples. Four soil samples shall be taken from each 5-five feet soil borings at 0-3 inches, 3-6 inches, 6-12 inches, and 2 feet. Six soil samples shall be taken from the 10-ten feet soil borings at 3-4, 4-5, 5-6, 7-8, 8-9, and 9-10 feet from the unpaved areas. Begin collecting samples at the soil level. A total of eighty soil samples from the soil borings will be submitted for chemical analysis from this site.

2.2 Analytical. Analyze eighty soil samples for lead. Refer to Table 1-1 for frequency of QA/QC samples.

3. Granite City Residential Areas 2-8.

3.1 Collection of Analytical Samples. Three soil samples shall be taken from the two sampling locations at each residential lot. Samples shall be taken at 0-3 inches, 3-6 inches, and 6-12 inches. Approximately 750 residential lots shall be sampled. Six samples shall be submitted from each residential lot for a total of four thousands five hundred samples submitted for chemical analysis from this site.

3.2 Analytical. Analyze four thousand five hundred samples for lead. See Table 1-2 for frequency of QA/QC samples.

4. Madison Community.

4.1 Collection of Analytical Samples. Three soil samples shall be taken from the two sampling locations at each residential lot. Samples shall be taken at 0-3 inches, 3-6 inches, and 6-12 inches. Approximately 500 residential lots shall be sampled. Six samples shall be submitted from each residential lot for a total of three thousands samples submitted for chemical analysis from this site.

4.2 Analytical. Analyze three thousand samples for lead. See Table 1-3 for frequency of QA/QC samples.

5. Surrounding Communities. The surrounding communities include four discrete areas as described below:

5.1 Illinois Route 3, South of Pontoon Road, North of the A.O. Smith Company. This residence has a parking lot approximately 200 x 150 feet and three smaller areas that contain hard rubber. The A-E shall inspect and map out these areas to determine the approximate volume of the fill material to be excavated.

5.2 Illinois Route 3 (just off of these road), South of Interstate 270, 50-100 feet of an old road had been filled in with the hard rubber. This area is located on three different pieces of property with Illinois Power owning the majority of the property. The A-E shall inspect and map out these areas to determine the approximate volume of the fill material to be excavated.

5.3 2230 Cleveland Ave., Granite City. The driveway and floor of the garage contains hard rubber. The A-E shall inspect and map out this area to determine the approximate volume of the fill material to be excavated.

5.4 Along Chain-of Rocks Road, near Sand Road, Northeast of Granite City in a farmer's field is part of an old foundation of a house that contained hard rubber. The A-E shall inspect and map out this area to determine the approximate volume of the fill material to be excavated, if any.

5.4.1 Collection of Analytical Samples. Four soil samples shall be taken from three sampling locations within the area believed to be contaminated. Samples shall be taken at 0-6 inches, 6-12 inches, and one foot increments thereafter to the bottom of the hard rubber plus one foot. Approximately twelve samples shall be submitted for chemical analysis from this site.

5.4.2 Analytical. Analyze twelve soil samples for lead. Refer to Table 1-4 for frequency of QA/QC samples.

6. Eagle Park Acres. Six areas in Eagle Park Acres contain hard rubber that has been used as fill material. Four core samples per residential lot in these six areas shall be taken to determine an average volume of fill material. The six areas include the following: 1) a driveway, 2) garage foundation (floor), 3) old parking lot (2 lots), 4) an empty lot which used to be a parking lot (one entire lot), 5) an empty lot with hard rubber casings all over the surface of the lot, and 6) an area which includes four residential lots. Sample at one foot intervals to determine the bottom of fill areas. The A-E shall inspect and map out these areas to determine the approximate volume of the fill material to be excavated.

6.1 Collection of Analytical Samples. Four soil samples shall be taken from three sampling locations within the area believed to be contaminated. Samples shall be taken at 0-6 inches, 6-12 inches, and one foot increments thereafter to the bottom of the hard rubber plus one foot. Approximately twelve samples shall be submitted for chemical analysis from each area defined above except the driveway for a total of sixty samples submitted.

6.2 Analytical. Analyze sixty soil samples for lead. Refer to Table 1-5 for frequency of QA/QC samples.

7. Venice Alleys. Five alleys contain hard rubber that has been used as fill material. The alleys are from best to worst as follows: 1) Lincoln Alley-West side is paved, East side contains sparse and scattered hard rubber. 2) Oriole St. Alley - contains

sparse, scattered hard rubber. 3) Granville Alleys - contains scattered hard rubber. 4) Slough Road Alley - top fill composed of hard rubber. 5) Hampton Alley - large quantity of fill. The A-E shall inspect and map out these areas to determine the approximate volume of the fill material to be excavated.

8. Taracorp Site.

8.1 Collection of Analytical Samples. One sample from each of the four wells to be installed shall be taken. The existing wells shall also be sampled. A total of eighteen samples shall be submitted for chemical analysis from the wells.

8.2 Analytical. Analyze the eighteen samples for volatile organics, semivolatile organics, pesticides/PCBs, and TAL metals. Refer to Table 1-6 for frequency of QA/QC samples.

9. TCLP Analysis.

9.1 Collection of Analytical Samples. One sample from each of the above areas shall be submitted for chemical analysis. These areas include 1) Area 1 (one sample), 2) Areas 2-8 (seven samples), 3) Madison Community (five samples), 4) Surrounding Communities (Farmer's Field, one sample), and 5) Eagle Park Acres (one sample). The samples that contain the highest concentration of lead shall be the samples analyzed. A total of fifteen samples shall be submitted for chemical analysis from the five areas defined above.

9.2 Analytical. Analyze fifteen samples for lead TCLP. Refer to Table 1-7 for frequency of QA/QC samples.

TABLE 1-1
Area 1 - SLLR

PARAMETER	QUALITY CONTROL SAMPLES				QUALITY ASSURANCE SAMPLES		
	NO.OF FIELD SAMPLES	NO.OF DUPS/ SPLITS	NO.OF TRIP BLANKS	TOTAL AE SAMPLES	QA DUPS/ SPLITS	QA TRIP BLANKS	TOTAL QA SAMPLES
Lead	80	8	0	88	8	0	8

TABLE 1-2
Granite City Residential Areas 2-8.

PARAMETER	QUALITY CONTROL SAMPLES				QUALITY ASSURANCE SAMPLES		
	NO.OF FIELD SAMPLES	NO.OF DUPS/ SPLITS	NO.OF TRIP BLANKS	TOTAL AE SAMPLES	QA DUPS/ SPLITS	QA TRIP BLANKS	TOTAL QA SAMPLES
Lead	4500	450	0	4950	450	0	450

TABLE 1-3
Madison Community

PARAMETER	QUALITY CONTROL SAMPLES				QUALITY ASSURANCE SAMPLES		
	NO.OF FIELD SAMPLES	NO.OF DUPS/ SPLITS	NO.OF TRIP BLANKS	TOTAL AE SAMPLES	QA DUPS/ SPLITS	QA TRIP BLANKS	TOTAL QA SAMPLES
Lead	3000	300	0	3300	300	0	300

TABLE 1-4
Farmer's Field

PARAMETER	QUALITY CONTROL SAMPLES				QUALITY ASSURANCE SAMPLES		
	NO.OF FIELD SAMPLES	NO.OF DUPS/ SPLITS	NO.OF TRIP BLANKS	TOTAL AE SAMPLES	QA DUPS/ SPLITS	QA TRIP BLANKS	TOTAL QA SAMPLES
Lead	12	1	0	13	1	0	1

TABLE 1-5
Eagle Park Acres

PARAMETER	QUALITY CONTROL SAMPLES				QUALITY ASSURANCE SAMPLES		
	NO.OF FIELD SAMPLES	NO.OF DUPS/ SPLITS	NO.OF TRIP BLANKS	TOTAL AE SAMPLES	QA DUPS/ SPLITS	QA TRIP BLANKS	TOTAL QA SAMPLES
Lead	60	6	0	66	6	0	6

TABLE 1-6
TARACORP GROUNDWATER SAMPLES

PARAMETER	QUALITY CONTROL SAMPLES					QUALITY ASSURANCE SAMPLES			
	NO.OF FIELD SAMPLES	NO.OF DUPS/ SPLITS	NO.OF TRIP BLANKS	NO.OF RINSATE BLANKS	TOTAL AE SAMPLES	QA DUPS/ SPLITS	QA TRIP BLANKS	QA RINSATE BLANKS	TOTAL QA SAMPLES
VOAs	18	2	1	1	22	2	1	1	4
BNA	18	2	0	1	21	2	0	1	3
PCBs/ Pesticides	18	2	0	1	21	2	0	1	3
Metals	18	2	0	1	21	2	0	1	3

TABLE 1-7

PARAMETER	QUALITY CONTROL SAMPLES				QUALITY ASSURANCE SAMPLES		
	NO.OF FIELD SAMPLES	NO.OF DUPS/ SPLITS	NO.OF TRIP BLANKS	TOTAL AE SAMPLES	QA DUPS/ SPLITS	QA TRIP BLANKS	TOTAL QA SAMPLES
TCLP - Lead	15	1	0	16	1	0	1

10.4

SCOPE OF SERVICES
FOR
PRE-DESIGN WORK
NL INDUSTRIES/TARACORP
AT
GRANITE CITY, ILLINOIS

JULY 1991

3. Field Investigation - General The pre-design work for NL Industries/Taracorp will include the use of soil sampling to determine the vertical and horizontal extent of lead contamination. In addition, soil sampling will be done from the surrounding residential and industrial areas.

(a). General Specifications

(1) Field Sampling Plan - A Work Plan shall be submitted by the Contractor for approval before any field work can begin. This plan shall include, at a minimum, the Contractor's methods, equipment, and procedures for carrying out all field work including drilling; soil sampling; monitoring well installation; well development; ground water sampling; in-situ permeability testing; and decontamination procedures. This Plan shall identify the responsibilities of all personnel involved. Additional specific requirements which shall be discussed in this Plan may be identified throughout this document.

The Contractor shall provide a qualified geologist or soils engineer who shall be on-site and responsible for all soil sampling during the soil sampling activities. A qualified geologist or hydrogeologist shall be on-site and responsible for all ground water monitoring well drilling, installation, developing and testing.

(2). Utility Clearance and Permits - The specific locations of the borings are described in subsequent sections. The Contractor shall be responsible for obtaining the appropriate drilling permits from the county and shall be responsible for coordinating all utility clearances with the appropriate agencies. The Contractor shall be responsible for relocating holes as necessary for utility clearances to suitable locations which accomplish the intent of the original location. The Contractor shall take all reasonable precautions to protect persons and property near the drill site and shall attempt to restore the site to its original state upon completion of the field investigation.

(3) Boring Logs Each boring will be logged by a qualified geologist or soils engineer. Two copies of each field drilling log shall be sent to the CE PM within ten (10) days of the completion of drilling. An example of the drill log to be used is attached. Each drill log will contain the following information:

BOREHOLE LOGGING REQUIREMENTS:

(1) Logs shall be prepared in the field, as borings are drilled, by a qualified, experienced geologist or geotechnical engineer. Each log shall be signed by the preparer.

(2) All log entries shall be printed. Photo reproductions shall be clear and legible. Illegible or incomplete logs will not be accepted. Copies shall be submitted to USACEMRO as borings are completed.

(3) Borehole depth information shall be from direct measurements accurate to 0.10 feet.

(4) Logs shall be prepared on the attached sheets.

(5) All relevant information blanks in the log heading shall be completed. If surveyed horizontal control is not available at the time of drilling, location sketches referenced by measured distances to prominent surface features, shall be shown on, or attached to, the log.

(6) Log scale shall be 1 inch = 1 foot.

(7) Each and every material type encountered shall be described in column c of the log form.

(8) Unconsolidated materials shall be described as follows:

(a) descriptive USCS classification;

(b) consistency of cohesive materials or apparent density of non-cohesive materials;

(c) moisture content assessment, e.g., moist, wet, saturated, etc.;

(d) color;

(e) other descriptive features (bedding characteristics, organic materials, macrostructure of fine-grained soils; e.g., root holes, fractures, etc.);

(f) depositional type (alluvium, till, loess, etc.).

(9) Rock materials shall be described in accordance with standard geologic nomenclature, including:

(a) rock type;

(b) relative hardness;

(c) density;

(d) texture;

(e) color;

(f) weathering;

(g) bedding;

(h) fractures, joints, bedding planes, and cavities, including any filling material and whether open or closed; and

(i) other descriptive features (fossils, pits, crystals, etc.).

(10) Stratigraphic/lithologic changes shall be identified in column c by a solid horizontal line at the appropriate scale depth on the log which corresponds to measured borehole depths at which changes occur, measured and recorded to the nearest 0.1 foot. Gradational transitions, changes identified from cuttings or methods other than direct observation and measurement shall be identified by a horizontal dashed line at the appropriate scale depth based upon the best judgment of the logger.

(11) Logs shall clearly show in columns e and f, the depth intervals from which all samples are retained.

(12) Logs shall identify the depth at which water is first encountered, the depth to water at the completion of drilling and the stabilized depth to water. The absence of water in borings shall also be indicated. Stabilized water level data shall include time allowed for levels to stabilize.

(13) Logs shall show borehole and sample diameters and depths at which drilling or sampling methods or equipment change.

(14) Logs shall show total depth of penetration and sampling. The bottom of the hole shall be so identified on the log by solid double lines from margin to margin with the notation "bottom of hole."

(15) Logs shall identify any drilling fluid losses including depths at which they occur, rate of loss and total volume lost.

(16) Logs shall show drilling fluids used including, as appropriate:

(a) source of make-up water;

(b) drill fluid additives by brand and product name, and mixture proportions; and

(c) type of filter for compressed air.

(17) Logs shall show depths and types of any temporary casing used.

(18) Logs shall identify any intervals of hole instability.

(19) Intervals of lost bedrock core shall be shown in column e. Intervals of intact soil sampling attempts shall also be shown in column e, including depths from which attempts were made and length of sample recovered from each attempt. Bedrock coring information shall be recorded in consecutively numbered runs in column h and shall include the following:

(a) start and stop time of each core run;

(b) depth to top and bottom of each core run;

(c) length of core recovered from each run;

(d) size and type of coring bit and barrel; and

(e) measured depth to the bottom of the hole after core is removed from each run.

(20) Any special drilling or sampling problems shall be recorded on logs, including descriptions of problem resolutions.

(21) Logs shall include all other information relevant to a particular investigation, including but not limited to:

(a) odors;

(b) HNu/OVA measurements or other field screening or test results; and

(c) any observed evidence of contamination in samples, cuttings or drilling fluids.

(4) Water Source - Water for drilling, steam cleaning and other necessary field activities will be the Contractors responsibility. The Contractor shall be responsible for collecting and transporting all water to the drilling area for the required uses. The Contractor shall sample the water prior to its use on the site. The water shall undergo the same analysis as the ground water samples. The Contractor shall document the source location of the water. The Contractor shall furnish all deionized and distilled water necessary to perform sampling operations.

(5) Disposal of Drill Cuttings and Fluids - Fluids from drilling operations shall be placed in properly labeled drums that are DOT or EPA-approved for hazardous materials and shall be secured on-site pending receipt of analytical results. When analytical results are received, the Contractor shall submit a letter to the U.S. Army Corps of Engineers Project Manager (CE PM) describing the contents in each drum. All drums shall be properly sealed, labeled, and documented for disposal. The Contractor shall manifesting any drums which will be disposed of off-site at a licensed disposal facility. Actual disposal of non-hazardous cuttings onto the Taracorp pile shall be the responsibility of the Contractor.

(6) Site Restoration - The Contractor shall restore the site to its original state within ten working days of when the field investigations are complete. The restoration efforts shall meet the approval of the Taracorp officer.

(7) Survey of Borehole and Monitoring Well Locations - All soil borings shall be staked at completion to facilitate subsequent surveying. The elevation of the borehole shall be determined to the nearest foot. The location of each borehole shall be measured from permanent site features which will allow for later relocation of all sampling locations. These measurements shall be shown on a site plan and recorded in the surveying notebook. Coordinates and elevations

shall be established for each monitoring well. The coordinates shall be to the closest 1.0-foot and referenced to the State Plane coordinate System. A ground elevation to the closest 0.01-foot and an elevation for the top of the casing to the closest 0.01-foot shall be obtained for each well. The point on the well casing at which the elevation is taken shall be permanently marked on the well casing. These elevations shall be referenced to the existing local vertical Datum. The location, identification, coordinates and elevations of the wells shall be plotted on maps with a scale large enough to show their location with reference to other structures at the individual sites. A tabulated list of the monitoring wells, copies of all field books, and all computation sheets shall be prepared and submitted to the CE PM. The tabulation shall consist of the designated number of the well, the X and Y coordinates, and all the required elevations. These items shall be submitted to the Omaha District CE no later than the Draft Report.

Hand auger holes shall be located by drawing a representative map of each residential with measurements taken from existing features. Each map shall be of sufficient detail that the holes can be relocated by a licensed surveyor at a later time.

(b). Soil Sampling - A minimum of () soil borings will be required to determine and define the vertical extent of lead contamination. These borings will be augured/drilled and sampled according to the following requirements.

1. General - Soil samples shall be taken in accordance with the following general requirements. The volume of sample recovered shall be consistent with Paragraph 10.2 and 10.3 concerning SAMPLE HANDLING PROTOCOL, TO ER 1110-1-1, 1990 and great enough to provide the necessary sample volume for the required chemical analyses.

2. Backfilling - All borings (except hand auger borings) shall be backfilled with cement grout. The cement grout shall consist of a mixture of portland cement (ASTM C 150) and water in the proportion of not more than six (6) gallons of clean water per bag of cement (one cubic foot or 94 pounds). Additionally, 3 percent by weight of bentonite powder shall be added if permitted by state regulations. If bentonite is added, water content may increase to eight (8) gallons. All hand auger borings shall remove a plug of grass prior to sampling. Upon completion of sampling, each boring shall be backfilled with bentonite chips to a depth of 6-inches and filled with cuttings to the surface. The grass plug shall be replaced. Borings located in driveways and alley ways shall be backfilled with bentonite chips to a depth of 6-inches and filled with cuttings to the surface.

3. Soil Sampling for Geotechnical Analysis - In addition to soil samples for chemical analysis, soil samples for geotechnical analysis may be required at a site. These samples shall be taken as directed in the site-specific portion of the Scope. These samples shall only be taken when adequate sample volume is available to fulfill chemical analytical requirements. Samples for geotechnical samples are considered disturbed and can, therefore, be taken from portions considered unsatisfactory for chemical analysis (except slough). These samples are intended to provide simple engineering-property information. Geotechnical lab analyses shall be performed on the samples by the Contractor and shall provide soil particle gradation (by sieve and hydrometer), moisture content, and lab classification according to the USCS. Samples shall be shipped

to the lab in 8 oz. wide-mouth plastic or glass jars. The lids shall be secured with at least three (3) wraps of electrical tape to insure moisture retention. All geotechnical analysis results shall be included in the Draft and Final Reports.

4. Sampling Techniques - Soil samples for chemical sampling purposes will be taken with a stainless steel split-spoon sampler or auger, meeting the specifications of ASTM D1586-84, or with stainless steel thin-walled tubes. Soil volume recovered shall be adequate for analytical requirements. If it is not, another sample shall be attempted from immediately beneath the unsuccessful sample interval at no additional cost to the Government. All soil sampling will be done according to approved methodology as outlined in SW-846 and shall be described in the A-E QAPP. Homogenizing of soil samples shall be performed in a stainless steel bowl using stainless steel stirring devices that have been decontaminated prior to each homogenizing procedure. This decontamination procedure will be the same as specified for sampling equipment. Sampling equipment, methods and decontamination procedures shall be clearly indicated by the Contractor in the A-E QAPP.

(c) Ground Water Monitoring Wells

1. General - Ground-water monitoring wells shall be installed to identify the presence of ground-water contamination at Taracorp, and define ground-water flow directions. The design and construction of all monitoring wells sha be such that each well shall yield representative ground-water samples for che :al analysis, be compatible with the water quality at the site, and allow for the accurate measurement of ground-water elevations. The Contractor shall provide a hydrogeologist who will be on-site for all drilling, installation, development, and testing operations. Any state or local driller certification requirements shall be met. The Contractor shall be responsible for obtaining any well drilling permits required by the state or local authorities and for complying with state or local regulations concerning the submission of well logs and samples. Drilling permits and utility clearance requirements shall be met for all monitoring well installations. The monitoring wells shall be constructed and installed according to the following specifications. Site specific requirements are given under the appropriate paragraphs. Any conflicts between these specifications and state or local well construction requirements shall be brought to the attention of the CE PM for clarification as soon as possible.

2. Drilling Method and Protection of Water Yielding Zones - The Contractor shall use a drilling method consistent with the intent of the monitoring well program. Hollow-stem auger drilling is the preferred method of drilling if conditions permit. The use of any other drilling method or the addition of any water or other additives (bentonite, etc.) must be justified as necessary in the Field Sampling Plan and shall be approved by the CE PM before its use. The use of contaminating additives as part of the drilling fluids shall not be permitted. Grease or oil on drill rod joints is not permitted; however, Teflon tape shall be allowed and if used any applicable brand names shall be included on the drill logs. Dispersing agents (such as phosphates) or acids shall not be used in well installation and development. There shall be no attempt to chemically disinfect the well. The drill rig or rigs, drill tools and associated equipment shall be cleaned with steam prior to commencement of drilling at each well location. It is expressly understood that toxic and/or contaminating substances shall not be used during any part of the drilling, well installation,

or well development process. After development of each well a BART shall be run for Sulfate-reducing bacteria.

3. Well Design - All well materials shall be steam cleaned immediately before installation and shall remain clean until installed in the boring or the material shall be steam cleaned again. The following general specifications shall be followed except that site-specific requirements may be different where noted in the site-specific sections. All wells shall have a minimum 2-inch inside diameter.

a. Boring Diameter The boring diameter shall be of sufficient diameter to permit at least two (2) inches of annular space between the boring wall and all sides of the centered riser and screen. The boring diameter shall be of sufficient size to allow the accurate placement of the screen, riser and centralizers, filter pack, seal, and grout.

b. Riser - The well riser shall consist of new flush-threaded Schedule 80 PVC pipe. All PVC well risers shall, as a minimum, conform to the requirements of ASTM F 480- 88a for 2-inch diameter pipe and shall bear the markings that will identify the material as that which is specified. Riser sections shall be threaded, flush-joint couplings, to form water-tight unions. No lead shot or lead wool is to be employed in producing seals at any point in the well.

c. Screen - The well screens shall be constructed of minimum 2-inch (nominal) diameter PVC. The screen shall be non-contaminating, continuous wrap design. Field slotted screen is not permitted. The slot size shall be determined by the Contractor and designed to be compatible with aquifer and gravel pack material.

1. Screen Location - The Contractor shall have the responsibility of selecting the screened area of the borehole so that the completed monitoring well functions satisfactorily. Normal seasonal fluctuations in the water table elevation shall be taken into consideration when placing the well screen so that monitoring will be possible throughout the year. Normal fluctuations shall be determined through a review of local well records and available literature. The anticipated life of the well shall be a minimum of 30 years. The procedure to be used in the field for determining the screen placement shall be presented in the QAPP.

d. Filter Pack - The annular space around the well screen shall be backfilled with a clean, washed silica sand sized to perform as a filter between the formation material and the well screen. The filter pack shall extend from the bottom of the hole to at least two feet above the top of the screen.

e. Bentonite Seal - A bentonite pellet seal 2 feet thick shall be placed above the filter pack. The seal shall be composed of commercially manufactured sodium bentonite pellets tamped into place in the borehole and hydrated every ten (10) minutes for one-half hour with clean water. Four (4) hours shall elapse after hydration before placement of grout seal.

f. Grout Seal - Cement/bentonite grout shall be placed from the top of the bentonite seal to ground surface. The cement grout shall consist of a mixture of Portland cement (ASTM C 150) and water in the proportion of not

more than six (6) gallons of clear water per bag of cement (94 pounds). Three percent by weight of bentonite powder shall be added if permitted by state regulations. The A-E shall specify the method for grout sealing in the QAPP.

g. Vertical Alignment of Wells - All risers shall be set round, plumb, true to line. A 5-foot-long section of pipe 1-3/4 inch in diameter shall be run through the entire length of the well to verify the alignment. The performance of this test shall be documented in the Daily Quality Control Reports. If this test fails, the well will not be accepted, and the well shall be redrilled at no additional cost to the Government. The 5-foot-long section of pipe shall be decontaminated in the same manner as other sampling equipment.

h. Protection of Well - At all times during the progress of the work, precautions shall be used to prevent tampering with the well or the entrance of foreign material into it. Upon completion of the well, a suitable vented cap shall be installed to prevent material from entering the well. The steel well riser shall be surrounded by a larger diameter steel casing, rising 24-inches above the ground level and set into a concrete pad. The steel casing shall be provided with a locking cap and lock. All locks shall be keyed alike. The locks on existing wells which are monitored under this scope of work shall be exchanged so that all wells will have the same locks. A minimum three-foot square, four-inch thick concrete pad, sloped away from the well, shall be constructed around the well casing at the final ground level elevation. Three (3) two- inch diameter or larger steel posts shall be equally spaced around the well and embedded into concrete but not into the concrete pad. The ground immediately surrounding the top of the well shall be sloped away from the well. Each protective casing and their protective posts shall be painted by the Contractor.

i. Temporary Capping - Any well that is to be temporarily removed from service or left incomplete due to delay in construction shall be capped with a watertight cap and equipped with a "vandal proof" cover satisfying applicable state or local regulations or recommendations.

j. Well Construction Logs. Suitable logs detailing construction practices shall be maintained for inclusion in the draft and final reports. Final drafted construction logs shall be submitted in the Final Report. The logs shall be prepared by a qualified geologist present during all drilling operations. Two legible copies of each field well construction log shall be completed and sent to the USACE-PM within 10 days of each well completion. The well will not be accepted by the USACE-PM before the drill and construction logs are received or if not received within 10 days of completion. Information provided in the logs shall include, but not be limited to the following:

1. Reference elevation for all depth measurements.
2. Project and site names.
3. Well number.
4. Dates of installation.
5. The stratigraphic boundaries and thickness of each different stratum and a brief description of each stratum.
6. The depth at which the hole diameter changes.
7. The depth of the static water level and date of measurement.
8. Total depth of completed well.
9. Depth of any grouting or sealing.

10. Nominal hole diameters.
11. Amount of cement used for grouting or sealing.
12. Depth and type of well casing.
13. Description (to include length, location, diameter, slot sizes, material, and manufacturer) of well screen(s).
14. Any sealing-off of water bearing strata.
15. Static water level upon completion of the well and after development.
16. Drilling date or dates.
17. Other construction details of the monitoring well including amount, grain size and source of well filter pack material, and location of all seals and casing joints.
18. Top of riser pipe elevations (msl).

k. Monitoring Well Log Book A log book shall be prepared by the A-E for the purpose of maintaining a record of all personnel who access the monitoring wells. The log book shall contain the keys to the well and shall remain in the possession USACE upon conclusion of field activities. The log book shall include a listing of all existing monitoring wells to be used in the monitoring program and shall identify their locations by identification number and horizontal coordinates. A warning shall be clearly visible in the log book stating the responsibility of the individual to use special procedures that are required to protect the integrity of the wells and of the data obtained from them. The log book shall also contain a detailed description of the decontamination procedures required for any equipment entering the well. The book shall contain log pages that shall include, as a minimum, labeled columns for the date, individual's name and organization, well number, well location, and purpose or activity performed (i.e., sample, measure water level, etc.). The book shall be organized such that new wells can be easily added at a later date.

l. Identification of Wells - The A-E shall affix a permanent non-corrosive metal tag to the outer steel protective casing of each well which clearly identifies the well number, depth, screen depth, the U.S. Army Corps of Engineers, Omaha District, and the adjusted top casing elevation. The numbering system used shall be consistent with previous monitoring wells installed without duplication.

m. Contractor Responsibility for Monitoring Wells It is the responsibility of the A-E to properly plan, design, install, develop, and test monitoring wells so that they are suitable to produce representative ground water samples in sufficient quantity and quality for geochemical and analytical testing. The A-E shall ensure that the intentions of this Scope of Work and best construction practices are carried out. In addition, all new wells shall be registered with Illinois Environmental Protection Agency (IEPA) and any other state water enforcement agencies. Prior to abandoning any well the IEPA and state agencies shall be notified. A copy of the registration shall be included in the Draft/Final Report.

1. If the A-E, due to his inadequate design or construction, installs monitoring wells that are not functional or not in accordance with specifications, the USACE-PM will disapprove the well and direct the A-E to repair or replace it at the USACE-PM's direction. This work shall be done at no additional cost to the Government.

2. If a monitoring well is disapproved by the USACE-PM or is abandoned by the A-E for any reason,, the hole shall be backfilled with neat cement grout from bottom to top by the A-E at no additional cost to the Government. In addition, all abandoning reguirements set by the state shall be followed.

n. Well Development - After each well has been constructed, either before grouting or no sooner than 48 hours after grouting is completed, the Contractor shall direct a program for the development of the well without the use of dispersing agents, acids, or explosives. The objectives of well development are to: (a) assure that ground water enters the well screen freely, thus yielding a representative ground water sample and an accurate water level measurement; (b) remove all water that may have been introduced during drilling and well installation; and (c) remove very fine-grained sediment in the filter pack and nearby formation so that ground water samples are not highly turbid and so that silting of the well does not occur. Development shall consist of pumping and surging. Any pumping shall be at a rate equal to or greater than the anticipated purging/sampling rate. Any sediments brought into the well during development shall be removed from the well. Development shall continue for a period of four (4) hours. At the end of that time, five volumes of water shall be pumped from the well and a turbidity measurement according to ASTM D-1889 shall be taken. If the water is still cloudy or sediment is still entering the well, then pumping or surging shall continue for another four (4) hours and all sediment shall be removed from the well. Temperature, pH, and specific conductivity shall be monitored throughout the development. If these parameters have not stabilized (< a 10 percent change between four consecutive readings) after the described activities have been completed, then the CE PM shall be contacted for further direction. Equations to be used to determine amount of ground water to be removed shall be proposed in the Field Sampling Plan. All calculations shall be included in the Draft and Final Report.

The utmost care must be taken not to collapse well screens during development activities and at least as much water as was introduced during drilling shall be removed from each well. After final development of the well, the Contractor shall collect approximately one (1) liter of water from the well in a clear glass jar, label and photograph it with a 35mm color slide, and submit the slide as part of the well log. The photograph shall be a suitably back-lit close-up which shows the clarity of the water. The nephelometric turbidity of the water shall be determined in accordance with ASTM D-1889 and shown on the final well construction log.

o. In-Situ Permeability Determination - After development of the monitoring wells, the Contractor shall determine for each well at each site the in-situ permeability of the screened formation using an appropriate method. The Contractor shall propose the methods expected to be used and references for those methods in the Field Sampling Plan. However, no water or other liquid may be introduced into the well other than formation water from that well.

p. Abandoning Wells - If a well must be abandoned, for any reason, the hole must be backfilled with a neat cement grout. The grout shall be placed through a tremie pipe starting at the bottom of the hole and working up to the top. The grout mixture shall be as stated in paragraph 3,(c),(3) (f).

(7) Ground Water Sampling

a. General - Each of the ground water monitoring wells, after it has been developed and no sooner than 2 weeks after completion, shall be sampled. In addition, all existing wells shall be sampled at the same time. This shall serve as the first semi-annual sampling round for the 30-year monitoring program. Before a sample is collected from a well, the water level and well depth shall be measured and recorded. Calculations shall be made to determine 5 casing volumes to be removed prior to sampling. Methods and equipment to be used shall be included in the Field Sampling Plan.

b. Ground Water Level Measurements - Prior to ground water sampling a complete round of ground water elevation measurements shall be taken from each newly installed monitoring well and each existing monitoring well. These measurements shall be taken within a 24-hour period. The time and date of measurement, well depth, and weather conditions at time of measurement shall be recorded.

c. Surveys

1 General - The Contractor shall perform all surveys required for this project including those already discussed and shall supply the USACE survey office with the original or a legible reproducible copy of the surveys and field notebooks.

(8) Geotechnical Sampling.

a. Sample Collection. Samples for geotechnical testing and lithologic description shall be collected every 2.5 feet for the total fifteen feet of each boring.

b. Geotechnical Testing. Tests shall be performed according to the American Society for Testing and Materials (ASTM) standard procedures referenced below, or USACE ER 1110-2-1902. Gradation analyses (ASTM D 421 & 422), including hydrometer, shall be run on half of the samples collected. Atterberg limits (ASTM D 4318) shall be run on all cohesive soils collected. Moisture content (ASTM D 2216) shall be run on all samples collected. If the specified number of tests are insufficient to adequately characterize all strata found at the site, contact the USACE Project Manager for further instructions.

Consolidation tests are not required for the existing or proposed stockpile areas if subsurface soils are found to be cohesionless. However, if clay strata or seams are found, then a sample should be taken and consolidation tests run on the sample.

(9) Preliminary Borrow Site Activities. The quantity of borrow materials required for the cap remedy recommended in the Record of Decision shall be estimated. Locations of potential borrow for random fill and clay (permeability of less than 1 X 10-7) shall be identified. The scope of this investigation shall consist of a review of soil surveys, USDA and USGS information, and available test results. In addition, an estimate of the quantity of borrow materials available at each potential borrow source identified shall be made. The availability of on-site borrow should be evaluated.

(10) Treatability Testing Scopes. A scope of work for a treatability testing for soil washing of the material that does not pass the TCLP test as discussed in the ROD shall be prepared. The ROD states that all material from off of the Taracorp site that is not toxic will be consolidated into the Taracorp pile. Material that is toxic will be treated or placed in a RCRA-compliant landfill.

(11) RCRA Landfill Location. The nearest RCRA-compliant landfill shall be located. The cost per unit for landfilling the material that does not pass the TCLP testing shall be determined. Requirements for landfilling this material shall be identified.

(E) Site Specific All work for this work effort will be performed under the supervision of a Professional Engineer, a Professional Geologist, a Chemist, and a Certified Industrial Hygienist. The Contractor shall refer to the Geology and Chemistry Appendices, also included in the Scope of Services, as guidance documents in planning and carrying out the field tasks presented in this portion of the Scope.

(1) Area 1 - SLLR Pile

a. Soil Borings

1. Installation and Rationale A total of fifteen (15) soil borings will be needed to determine the vertical extent of lead contamination around the SLLR pile and site. Five (5) borings shall be evenly spaced around the pile. The borings shall be 15 feet in depth for a total of 75 feet of drilling. Ten (10) soil borings will be needed to determine the vertical and horizontal extent of lead contamination. The holes will be 10 feet in depth for a total of 100 feet of drilling. Boring locations shall be proposed for approval in the Chemical Data Acquisition Plan (CDAP).

2. Collection A total of twenty (20) chemical soil samples will be collected from the 15 feet soil borings (4 per boring). Samples shall be taken from 0-3 inches, 3-6 inches, 6-12 inches, and 2 feet. A total of sixty (60) samples will be collected from the 10 feet soil borings (6 per boring). Samples will be taken from 4-5 feet, 5-6 feet, 6-7 feet, 7-8 feet, 8-9 feet, and 9-10 feet and submitted for chemical analysis. In addition, geotechnical samples will be taken as specified in 3(c)(8)(a)1.

3. Analysis All eighty (80) samples will be analyzed for the following:

a. Lead content

Geotechnical samples will be tested according to 3(c)(8)(a)2

(2) Areas 2 thru 8 - Granite City Residential Areas

(a) Soil Borings

1. Installation and Rationale A total of two (2) hand auger holes will be needed to determine the vertical and horizontal extent of

lead contamination per residence. The holes will be 1 foot in depth for a total of 2 feet of auguring. Locations shall be proposed for approval in the CDAP.

2. Collection A total of six (6) samples (three per hole) will be submitted for chemical analysis from each residence. Samples shall be taken from 0-3 inches, 3-6 inches, and 6-12 inches. Approximately 750 residential lots shall be sampled.

3. Analysis All four thousand five hundred (4500) samples (6 per residence) will be analyzed for the following:

a. Lead content

(3) Madison Community Approximately five hundred (500) residential lots will be investigated.

(a) Soil Borings

1. Installation and Rationale A total of two (2) hand auger holes will be needed to determine the vertical and horizontal extent of lead contamination. The holes will be 1 foot in depth for a total of 2 feet of auguring. Locations shall be proposed for approval in the CDAP.

2. Collection A total of six (6) samples (three per hole) will be submitted for chemical analysis from each residence. Samples shall be taken from 0-3 inches, 3-6 inches, and 6-12 inches.

3. Analysis All three thousand (3000) samples (six per residence) will be analyzed for the following:

a. Lead content

(4) Surrounding Communities The surrounding communities include four (4) discrete areas as described below:

a. Illinois Route 3, south of Pond Tune Road, North of the A.O. Smith Company. This residence has a parking lot approximately 200 X 150 feet and three smaller areas that contain hard rubber. The A-E shall inspect and map out these areas to determine the approximate volume of the fill material to be excavated.

b. Illinois Route 3 (just off of these roads), South of Interstate 270, 50-100 feet of an old road that has been filled with hard rubber. This area is located on three different pieces of property with Illinois Power owning the majority of the property. The A-E shall inspect and map out these areas to determine the approximate volume of the fill material to be excavated.

c. 2230 Cleveland Ave., Granite City. The driveway and floor of the garage contains hard rubber. The A-E shall inspect and map out this area to determine the approximate volume of the fill material to be excavated.

d. Along Chain-of-Rocks Road, near Sand Road, Northeast of

Granite City in a farmer's field is part of an old house foundation that contained hard rubber. The A-E shall inspect and map this area to determine the approximate volume of the fill material to be excavated, if any.

1. Installation and Rational A total of three (3) hand auger holes will be needed to determine the vertical and horizontal extent of lead contamination. The holes will be 2 foot in depth for a total of 6 feet of auguring. Locations shall be proposed for approval in the CDAP.

2. Collection A total of twelve (12) samples (four per hole) will be submitted for chemical analysis from each residence. Samples shall be taken at 0-6 inches, 6-12 inches, and one foot increments thereafter to the bottom of the hard rubber plus one foot.

3. Analysis All twelve (12) samples will be analyzed for the following:

a. Lead content

Soil borings will be installed for the purpose of volume determination at each site. Soil borings shall be logged by a geologist or soils engineer.

(5) Eagle Park Acres Six (6) areas contain hard rubber that has been used as fill material. Four borings per residential lot in the following six areas shall be drilled to determine an average volume of fill material. The six areas include : 1) a driveway, 2) garage floor foundation, 3) old parking area consisting of 2 lots, 4) an empty lot which used to be used as a parking lot, 5) an empty lot with hard rubber casings over the entire surface, 6) an area which includes four residential areas. Samples shall be taken at 1-foot intervals to determine the depth of fill material. The A-E shall inspect and map these areas to determine the approximate volume of fill material to be excavated. Soil borings shall be installed and logged by a geologist or soils engineer for fill volume determination.

a. Installation and Rational A total of three (3) hand auger holes will be needed to determine the vertical and horizontal extent of lead contamination. The holes will be 2 foot in depth for a total of 30 feet of auguring. Locations shall be proposed for approval in the CDAP.

b. Collection Four soil samples shall be taken from three sampling locations within the area believed to be contaminated. Samples shall be taken at 0-6 inches, 6-12 inches, and one foot increments thereafter to the bottom of the hard rubber plus one foot. Approximately twelve samples shall be submitted for chemical analysis from each area defined above except the driveway for a total of sixty samples submitted.

c. Analysis All sixty (60) samples will be analyzed for the following:

1. Lead

(6) Venice Five (5) alleys contain hard rubber that has been used as fill material. The alleys are from best to worst as follows: 1) Lincoln Alley-west side is paved, east side contains sparse and scattered hard rubber, 2) Oriole Street Alley - contains sparse, scattered hard rubber, 3) Granville

Alleys - contains scattered hard rubber, 4) Slough Road Alley - top fill composed of hard rubber, 5) Hampton Alley - large quantity of fill. The A-E shall inspect and map out these areas to determined the approximate volume of the fill material to excavated. Soil borings shall be installed and logged by a geologist or soils engineer for fill volume determination.

(7) Taracorp Site

(a) Monitoring Wells

1. Installation and Rationale Four (4) deep monitoring wells will be installed to monitor the ground water around the Taracorp pile. One (1) well will be located upgradient of the pile and three (3) wells will be located downgradient of the pile. Each well shall be 70 feet in depth for a total of 280 feet of drilling. The wells will be installed according to previous sections of this scope. Locations will be located so that the objective is met and the possibility of destruction during cap construction is eliminated. Monitoring well locations shall be proposed for USACE approval in the CDAP.

2. Collection A total of eighteen (18) samples will be collected for chemical analysis (4 new and 14 existing wells).

3. Analysis All eighteen (18) water samples will be analyzed for the following:

a. VOA's
b. BNA's
c. PCB/pest
d. Metals (TAL)

(b) Soil Borings

1. Installation and Rationale The geotechnical characteristics of the soil at the Taracorp site and at the proposed location of the lined fill area need to be determined. A total of 8 soil borings shall be drilled to collect samples for geotechnical analysis of the soils. The intent is to investigate the characteristics of the soils beneath the existing Taracorp pile and beneath the proposed location of the lined pile. Three (3) soil borings shall be taken around the Taracorp site area and five (5) soil borings shall be taken in the proposed liner area. Approximate locations are shown on the attached drawing. Boring locations shown on the drawing are general only and shall be moved and noted to a near-by location if obstacles are encountered. The actual boring locations and any offset borings shall be plotted on the site map. Samples shall be taken according to (3)(c)(8)(a).

(8) Additional Chemical Analysis

a. Collection A total of fifteen (15) samples shall be submitted from all areas investigated. One (1) sample from each area which exhibits the highest concentration of lead will be submitted for analysis.

b. Analysis All fifteen (15) samples shall be analyzed for the following:

1. Lead -TCLP

10.5

SCOPE OF WORK
SURVEYS AND MAPPING
GRANITE CITY, ILLINOIS

1.0 GENERAL: The work done under this contract consists of furnishing all services, labor, plant, equipment, materials and transportation necessary to produce vertical black and white aerial photography and photogrammetric mapping via CADD/GIS type software, supplemented by ground surveys for detail of the Granite City, Illinois, Taracorp site and vicinity. There will be two levels of photography and mapping associated with this contract.

The first level will be flown at a negative scale of 1"=200' (Exhibit A). The area highlighted in orange will be mapped at a scale of 1"=30' with a 1' contour interval. The mapping will be supplemented by a field survey.

The second level will be flown at a scale of 1"=300' (Exhibit B). The area highlighted in yellow will be planimetrically mapped at a scale of 1"=50' (no contours). Planimetric mapping will be required to support a means for automatic production of lot inventory and grading plans for each residential lot. One 8-1/2"x 11" sheet will be needed for each lot - generated automatically from the planimetric mapping via GIS type software. ARC/INFO from ESRI has the capability to perform this function via command language macros.

2.0 EXHIBITS: The following expendable exhibits are furnished by the Government.

Exhibit "A": Location map showing the required aerial coverage at a negative scale of 1"=200'. Highlighted in orange is the area to mapped at a scale of 1"=30'; 1' contour interval with supplemental surveys for the Granite City, Illinois, Taracorp site and vicinity.

Exhibit "B"; Location map showing required aerial coverage at a negative scale of 1"=300'. Highlighted in yellow is the area to be planimetrically mapped at a scale of 1"=50'.

Exhibit "C": 30" x 42" Omaha District sheet for aerial photo index.

Exhibit "D": EM 1110-1-1002 Survey Markers and Monumentation.

3.0 FLIGHT OPERATIONS:

3.1 Aircraft: The aircraft furnished under this contract shall be capable of stable performance at any altitude and air speed and shall be equipped with essential navigation and photographic instruments and accessories, all maintained in operational condition during the period of this contract, and all subject to the approval of the Contracting Officer's Representative. No windows shall be interposed between the camera lens system and the terrain. Also, the camera lens system shall not be in the direct path

of any exhaust gases or oil from aircraft engines.

3.2 **Flight Plan**: The minimum area(s) to be photographed are as indicated on maps provided for each photographic assignment. The Contractor shall design the flight line(s) for the photography to obtain proper stereoscopic photographic coverage.

3.3 **Scale of Photography**: The flight height above the average elevation of the ground shall be such that the negatives have an average scale suitable for attaining required photogrammetric measurement, map scale, contour interval and accuracy. Negatives having a departure from the specified scale of more than three (3) percent because of tilt or any changes in the flying height may be rejected.

3.4 **Overlap**: Unless otherwise directed by the Contracting Officer's Representative, the overlap shall be sufficient to provide full stereoscopic coverage of the area to be photographed, as follows:

3.4.1 **Endlap**: Unless otherwise specified, the endlap shall average not less than fifty-seven (57) percent or more than sixty-two (62) percent. Endlap of less than fifty-five (55) percent or more than sixty-eight (68) percent in one or more negatives may be cause for rejection of the negative or negatives in which such deficiency or excess of endlap occurs.

3.4.2 **Sidelap**: The sidelap shall average fifteen (15) percent on each side. Variation by more than five (5) percent may because for rejection.

3.5 **Crab**: Any series of two or more consecutive photographs crabbed in excess of eight (8) degrees as measured from the mean flight path of the airplane, as indicated by the principal points of the consecutive photographs, may be considered cause for rejection of the photographs. Average crab for any flight line shall not exceed 5 degrees.

3.6 **Tilt**: Negatives exposed with the optical axis of the aerial camera in a vertical position are desired. Tilt (angular departure of the aerial camera axis from a vertical line at the instant of exposure) in any negative of more than three (3) degrees, an average tilt of more than one (1) degree for the entire project, or tilt between any two successive negatives exceeding five (5) degrees may be cause for rejection.

3.7 **Substitute Photography**: In flight lines rephotographed to obtain substitute photography for rejected photography, all negatives shall be exposed to comply with flight specifications, including scale and overlap requirements. The joining end negatives in the replacement strip shall result in complete stereoscopic coverage.

3.8 **Flying Conditions**: Unless otherwise specified, photography shall be accomplished between the hours of 10:00 a.m. and 2:00 p.m., Local Standard Time, on days when well-defined images can be obtained. No sun spots shall be allowed. Photography shall not be attempted when the ground is obscured by haze, smoke or dust, snow or when the clouds or cloud shadows appear on more than five (5) percent of the area of any one photograph without the permission of the Contracting Officer's Representative. Photography shall not contain

shadows caused by topographic relief or sun angle, whenever such shadows can be avoided during the time of year the photography must be taken. Any day containing two or more consecutive hours of suitable flying conditions, in any sizable portion of the area not yet photographed, will be considered a suitable day for aerial photography.

3.9 **Flight Log:** For each flight day, the pilot or cameraman shall prepare a flight log containing the date, project name, aircraft used and names of crew members. In addition, the following shall be prepared for each flight line; altitude, camera, magazine serial number, f-stop, shutter speed, beginning and ending exposure numbers and times, and any other comments relative to the flight conditions. The flight logs shall be delivered to the Contracting Officer's Representative as specified in the work order.

4.0 AERIAL CAMERA:

4.1 **Type of Camera:** A single lens precise aerial mapping camera equipped with a high resolution, distortion free lens shall be used on all assignments. The camera shall function properly at the necessary altitude and under expected climatic conditions, and shall expose a 9-inch square negative. The lens cone shall be so constructed that the lens and focal plane are at the calibrated focal length. Fiducial markers and marginal data markers comprise an integral unit or are otherwise fixed in rigid orientation with one another. Dimensional changes brought about by variations of temperature or other conditions shall not be of such magnitude as would cause deviation from the calibrated focal length in excess of plus or minus 0.05 millimeters or would preclude determination of the principal point location to within plus or minus 0.003 millimeters.

4.2 **Calibration:** The aerial camera(s) furnished by the Contractor shall have been calibrated by the U.S. Geological Survey within three (3) years of award of this contract. Camera features and acceptable tolerances are as follows:

4.2.1 **Focal Length:** The calibrated focal length of the lens shall be 153 millimeters, plus or minus 3 millimeters, measured to the nearest .001 millimeter.

4.2.2 **Platen:** The focal plane surface of the platen shall be flat to within 0.013 millimeters and shall be truly normal to the optical axis of the lens. The camera shall be equipped with means of holding the film motionless and flat against the platen at the instant of exposure.

4.2.3 **Fiducial Marks:** The camera shall be equipped with a minimum of four (4) fiducial marks, with eight (8) preferable, for accurately locating the principal point of the photograph. The lines joining opposite pairs of fiducial marks shall intersect at an angle within one minute of 90 degrees.

4.2.4 Lens Distortion: The absolute value of radial distortion measured at maximum aperture, as stated in the calibration report, shall not exceed .01 millimeter. The tangential distortion shall not exceed .005 millimeters.

5.0 AERIAL FILM:

5.1 **Type of Film Required:** The Contractor shall furnish appropriate black and white aerial film of a quality that is equal or superior to 4 mil Kodak Double-X Aerographic 2405 (Estar Base) panchromatic film. Only fresh, fine grain, dimensionally stable, and safety base aerial film shall be used. Outdated film shall not be used.

5.2 **Processing of Exposed Film:** The processing, including development and fixation, and washing and drying of all exposed photographic film shall result in negatives free from chemical or other stains, containing normal and uniform density, and fine-grain quality. Before, during and after processing, the film shall not be rolled tightly on drums or in any way stretched, distorted, scratched, or marked, and shall be free from finger marks, dirt, or blemishes of any kind.

5.3 **Quality of Photography:** The photographic negatives shall be taken so as to prevent appreciable image movement at the instant of exposure (i.e. use a forward motion compensator [FMC]). The negatives shall be free from static marks, shall have uniform tone, and shall have the proper degree of contrast for all details to show clearly in the dark-tone areas and high-lighted areas as well as in the half-tones between the dark and the light. Negatives having excessive contrast or negatives low in contrast may be rejected.

5.4 **Unexposed Film:** Whenever any part of an unexposed roll of film remains in the camera, before such film is used on a subsequent day, a minimum three-foot section of the roll of film shall be rolled forward unexposed immediately proceeding the beginning of photography.

5.5 **Labeling:** Each negative shall be labeled clearly with the following: DATE, PROJECT SCALE, CONTRACT NO., FLIGHTLINE-FRAME. The frame numbers shall be sequential within each flight line and shall be in the upper right hand corner of the negative to be read as one looks northerly along the flight line (or easterly when lines are east-west). All lettering and numbering of negatives shall be one-fifth (1/5) inch high and shall result in easily read, sharp, and uniform letters and numbers.

5.6 **Deliveries:** All negatives shall be delivered to the Contracting Officer's Representative on winding spools, in plastic canisters, with each canister labeled to show the name and address of the contracting agency, name of the project, designated roll number (provided by the Contracting Officer's Representative), numbers of the first, and last numbered negatives of each strip, date of each strip, approximate scale, focal length of lens in millimeters, contract number and the name and address of the Contractor who accomplished the photography. At least three (3) feet of clear film shall be left on or spliced to each end of the roll. All splices shall be of a permanent nature.

6.0 CONTACT PRINTS:

6.1 **Material:** All contact prints shall be made on medium weight (RC) semi-matte paper stock approved by the Contracting Officer's Representative.

6.2 **Processing and Quality:** The processing shall result in finished photographic prints having fine-grain quality, normal uniform density, and such tone and degree of contrast that all photographic details of the negative from which they are printed show clearly in the dark-tone areas and high light areas as well as in the half tones between the dark and the high light. Excessive variance in tone or contrast between individual prints will be cause for their rejection. All prints shall be clear and free of stains, blemishes, uneven spots, air bells, light fog or streaks, creases, scratches, and other defects which would interfere with their use or in any way decrease their usefulness.

6.3 **Trimming:** All contact prints shall be trimmed to neat and uniform dimensional lines along image edges (without loss of image) leaving distinctly the camera marks. Prints lacking fiducial marks shall be rejected.

6.4 **Deliveries:** All prints shall be delivered to the Contracting Officer's Representative in a smooth, flat, and usable condition.

7.0 PHOTOGRAPHIC INDEX:

7.1 **General:** This item shall consist of one or more photographic negatives, as necessary, and photographic print or prints thereof, of an assembly of aerial photographs forming an index of the project aerial photography.

7.2 **Assembly:** The index shall include photographic prints made from all negatives of the photography taken and accepted for the project. The prints shall be trimmed to a neat and uniform edge along the photographic image without removing the fiducial marks. The photographs shall be overlap-matched by conjugate images on the flight-line with each photograph identification number clearly shown. The photographs for each adjacent flight-line strip shall overlap in the same direction. Airbase lengths shall be averaged in the image matching of successive pairs of photographs on flight-lines, and adjoining flight-line assemblies shall be adjusted in length by incremental movement along the flight-line as necessary.

7.3 **Labeling and Titling:** For geographic orientation, appropriate notations shall appear on the index, naming or otherwise identifying important and prominent geographic and land use features. All overlay lettering and numbering shall be neat and readable. In addition, a north arrow, sheet index, if applicable, and a title block shall appear on each index. Title block shall contain project name, contractor's name, contract agency name, date of photography and scale of photography.

7.4 **Scale and Size:** The photo index negative shall be prepared at a scale about one-third (1/3) of the original negative scale, except that a slightly smaller photo index scale can be used if all exposures for one

project fit the required format on a single sheet. Each photo index negative shall be on a 30" by 42" district sheet (see exhibit "C").

7.5 Photographic Copying and Printing: The index shall be copied on photographic film so that prints can be made by contact method.

7.6 Processing and Quality: All photographic prints of the index shall comply with the stipulations for contact prints in paragraph 6.2 of these instructions.

8.0 DIAPOSITIVES:

8.1 Type of Diapositive: All black and white diapositive transparencies shall be equal or superior to .130-inch thick Kodak Aerial Plotting Plates or .007-inch thick Dupont Diapositive Film, No. CT-7.

8.2 Processing and Quality: All diapositives shall comply with the stipulations for contact prints in paragraph 6.2 of these instructions.

8.3 Data Recording: All diapositive transparencies shall include information on the film which aids in correlation of the photography with the data produced by positioning equipment, airborne profile recorders, and other airborne instruments. Also, other data useful during map compilation shall be recorded.

9.0 GROUND CONTROL:

9.1 Targets: All ground control used as photographic control points will be premarked prior to obtaining aerial photography. Targets shall be of adequate size, and provide good photographic contrast so they will be clearly distinct in stereoscopic models.

9.2 Control Surveys: All horizontal and vertical control surveys required for photogrammetric mapping shall conform to third-order standards and shall be accomplished using third-order methods, or better procedures, and equipment. Ensure area to be mapped is fully bounded by Horizontal and Vertical control. Taracorp piles must be held to vertical mapping standards.

9.3 Photogrammetric Control: For elevational and planimetric mapping the contractor shall establish a minimum of two (2) two horizontal and (4) four vertical control points for each stereoscopic model by field survey methods. The horizontal points shall be as far apart as feasible within each model. Each point shall be an image of an existing object or be a finite photographic pattern which is clearly identifiable both on the ground and on the photographs, or be the photographic target. The vertical points shall be spaced for optimum use of the model, preferably, in or near each corner of the model. The accuracy of all photogrammetric control surveys shall be as stipulated in paragraph 9.2 of this instructions. For planimetric mapping, the contractor shall establish the minimum number of horizontal and vertical control points required to maintain horizontal accuracy within National Map Accuracy Standards.

9.4 Datums: Use National Geodetic Vertical Datum 1929 and 1927 or 1983 North American Datum State Plane zone.

9.5 Control Photographs: All horizontal and vertical control points including supplemental control points shall be marked and labeled with appropriate point identification number. All control points not premarked shall be neatly pin-pricked and described on the back of the photograph. No point shall be pin-pricked on more than one photograph.

10.0 AEROTRIANGULATION:.

10.1 General: The Contractor will determine the X, Y & Z coordinates for all photogrammetric control points using fully analytical aerotriangulation methods.

10.2 Equipment: The photogrammetric instruments shall have sufficient accuracy and utility for measuring the X and Y photographic coordinates of the fiducial or other photographic reference marks, targets, photographic images, and artificially marked points to achieve the required accuracies.

10.3 Accuracy: The root mean square error for the X, Y and Z coordinates of all photogrammetric control points determined by analytical aerotriangulation shall not be in error by more than 1:9000 in a horizontal position (X and Y) and 1:6000 in elevation (Z) when expressed as a fraction of the flying height.

10.4 Supplemental Control: All supplemental control points will be physically drilled (pugged) on the aerial photo. Insofar as practical, there shall be no less than six (6) supplemental control points established for each stereoscopic model. A supplemental control point shall be located at or near each corner of the model, preferably, in the overlap area between adjacent models and strips. A ground control point may be substituted for a supplementary control point if it is located in the same general area of one of six (6) positions described herein.

10.5 Control Points: The image of all ground control and supplemental control points shall be appropriately marked and identified on a set of contact prints. The identifying number for each supplemental control point shall be related to the photograph on which it appears and not exceed (4) digits.

10.6 Deliveries: All materials including, a X,Y and Z coordinate listing of supplemental control points, final adjustment including computations with error of closure, the closure prints, and diapositives, and any roll-film negatives used by the Contractor shall be provided to the Contracting Officer's Representative as specified in detailed specification work order.

11.0 STEREO COMPILATION:

11.1 General: The area to be mapped will be outlined on a project map.

11.2 Stereoplotter Requirement: All map compilation shall be accomplished with an optical-train, first-order stereoplotter. Direct enlargement from negative scale to compilations scale shall range from six (6) to eight (8) diameters and be within the stereoplotter's capability to produce maps having required accuracies specified in paragraph 13.7 of these instructions, as applicable.

11.3 Map Contents (also see paragraph 13.3.1):

11.3.1 Coordinate Grid: Grid ticks of the applicable State Plane Coordinate System shall be properly annotated at the top and right edges of each sheet within the map data. Spacing of the grid ticks shall be five (5) inches.

11.3.2 Control: All horizontal and vertical ground control determined by field methods shall be shown on the map.

11.3.3 Planimetry: The maps shall contain all planimetric features which are visible or identifiable on, or are interpretable from aerial photographs, including, but not limited to, buildings, roads, sidewalks, rivers, reservoirs. railroads, power poles, wooded areas, individual trees, bridges, piers, and dams.

11.3.4 Topography: Where applicable, the map shall contain all representable and specified topographic features which are visible or identifiable on, or are interpretable from aerial photography. Each contour shall be drawn sharp and clear as a solid line, except through densely wooded areas where the ground cannot be seen and where it is obscured by an overhanging bluff or ledge. In such ground hidden places, the contours shall be shown as dashed (broken) lines. Every fifth contour (index contour) shall be accentuated as a heavier line than the intermediate four and shall be numbered according to its actual elevation above mean sea level. Whenever index contours are closer than one-quarter (1/4)-inch, and the ground slope is uniform, the intermediate four may be omitted. Labeling or numbering of contours shall be placed so that the elevation is readily discernible. Labeling of intermediate contours may be required in areas of low relief.

11.3.5 Spot Elevations: Spot elevations determined photogrammetrically shall be shown on maps in proper position at water level on the shoreline of lakes, reservoirs, ponds and the like; on hilltops; in saddles; at the bottom of depressions; at intersection and along centerlines well traveled roads; principal street in cities, railroads, levees, and highways, and at centerline of end of bridges. In areas where contours are more than three inches apart at map scale, spot elevations shall also be shown and the horizontal distance between the contours and such spot elevations or between the spot elevations shall not exceed two (2) inches at scale of delivered maps.

11.3.6 Match Lines: Match lines shall be provided so that each sheet may be joined accurately to adjacent sheets. See paragraph 14.1 for data window requirements.

11.3.7 Symbols and Names: The symbols to be used for major planimetric and topographic features shall be in accordance with symbols provided by the Contracting Officer's Representative. The names of cities, towns, villages, rivers, streams, roads, streets, highways, and other features of importance shall be obtained by the Contractor. All names and numbers shall be legible and clear in meaning and shall not interfere with map features.

11.3.8 Lot Ownership: Lot line overlay information shall be gathered by the contractor from Granite City and delineated in the residential areas of the 1" = 50' planimetric mapping. A note in the map margin shall indicate the source and reliability of lot information.

11.4 Compilation History: A compilation history (model diagram) shall be prepared for each stereoscopic model used to accomplish the mapping. History shall include, but not be limited to the final photographic fit to X, Y and Z coordinates of ground and supplemental control points and any other problems encountered in the model orientation and compilation process. History shall also include the project name, flight date, photo scale, map scale, stereoplotter used, and the operator name.

11.5 Quality: The professional standards of draftsmanship shall be maintained throughout the mapping process. All symbols, lines, letters and numbers shall be clear and legible and conform with the standards specified by the Contracting Officer's Representative in accordance with detailed specifications in work order.

12.0 QUALITY OF WORK AND MATERIALS:

12.1 Work: The Contractor shall be responsible for field checking and editing the photogrammetrically made measurements and compiled maps to ascertain their completeness and accuracy. Also, the Contractor shall make additions and corrections necessary to complete the maps and photogrammetrically made measurements.

12.2 Materials: All materials, supplies or articles required for work which are not covered herein shall be standard products of reputable manufacturers and entirely suitable for the intended purpose. They shall be new, unused and subject to approval by the Contracting Officer's Representative.

13.0 SUPPLEMENTAL FIELD SURVEYS: Exhibit "A" Orange Area

13.1 General: Supplemental field surveys and/or premarking of small features will be required to collect the level of detail and accuracy required by this mapping. This work and any other ground work at the site including primary and photogrammetric ground control will require crew personnel who

have had baseline physicals and 40 hour course "Health and Safety for Hazardous Waste Operations" per OSHA 29 CFR 1910.120. The Taracorp site, exhibit "A" Orange, will be topographically surveyed where needed as a supplement to the aerial survey at a density compatible with 1" = 30' accuracy and incorporated with the 1" = 30'; 1 foot contour interval mapping.

13.2 Control; A minimum of three intervisible permanent horizontal control monuments shall be established adjacent to the site. These monuments are to be placed in strategic locations so as to be used for but not destroyed by grading or construction. They are to be assigned 3rd order State Plane coordinates and 1929 Mean Sea Level elevations. The contractor shall compute one combination factor for the area, as a minimum requirement. Additional combination factors may be required for certain sections if the terrain varies significantly. The respective combination factor, or factors, shall be noted on each segment. (Reference enclosed EM 1110-1-1002 Survey Markers and Monumentation for guidance in establishing these markers, Exhibit "D".) Type G monuments with 3/4" pipe or rebar will be the minimum accepted monument for third order horizontal and vertical control required.

13.3 Topographic Surveys: The supplemental data required will be ground surveyed by use of a total station and data collector for automatic topo recording. Accuracy of ground shots will be held to +/- 0.1 foot in all dimensions. Hardened surface elevations will be held to +/-0.1 foot horizontally and +/-0.03 foot vertically. Topographic surveys will be referenced to primary control established on benchmarks described above. Secondary networks will be used to set temporary marks from which the data may be radially collected.

13.3.1 Planimetric Features: All surfaces features within the area to be surveyed shall be shown and identified on the 1 inch = 30 feet mapping. These features may be surveyed photogrammetrically or on the ground. All features must be shown, however, and will be held to National Map Accuracy Standards. The phrase "surface features" is intended to include, but is not necessarily limited to, the following:

13.3.1.1 Power lines and communication lines, street light poles, guy wires, vaults (including handholes and manholes), transformers and substations.

13.3.1.2 Sanitary and industrial sewer manholes and storm drainage structures, such as culverts, headwalls, inlets, cleanouts, and manholes. Always obtain an elevation at the flow line at the bottom of all the pipes connected to a manhole or inlet (invert elevations). Clearly identify the size, direction and type of each pipe. Obtain the pipe invert elevation upstream and downstream of all manholes by popping all manholes, and inlets even if beyond the limits of the required topo. Provide sketches where needed for detail and clarity.

13.3.1.3 Water, gas and other above-ground pressure pipes. Locate all fire hydrants, hose bibs, valve meter, regulators, etc. within the limits of the area to be surveyed. Include location of pressure pipes on the topo map. Use sketched inserts where needed for detail and clarity.

13.3.1.4 Roads, drive, walks, and railroads. All roads shall have elevations at 30 feet intervals along the centerline and each edge of road. Type of surface shall be shown by text.

13.3.1.5 Fences (location, type and height).

13.3.1.6 Trees. Locate tree line of masses and locate individual trees. Indicate type and average diameter on topo sheets. The diameter is measured five feet above natural ground. Show all trees that are individually isolated outside of the tree line by appropriate symbol.

13.3.1.7 Ditches, streams, canals.

13.3.1.8 Other visible surface features. Locate any storage tanks, radio antennas, or other surface features visible and located within the area to be surveyed. Areas with active erosion shall be noted and located.

13.3.1.9 Underground utilities will be shown on the finished map. Location of underground utility lines should be from the most accurate information available. The source of utility information shall be noted on the map. Field location by respective utility agencies is desirable over as-built or historical utility drawings. The type and size of each utility shall be annotated.

13.3.2 Established Elevations: Spot elevations affecting the design of the facilities shall be provided, such as ground elevations on existing utilities, and visible surface features within the area to be surveyed. Specifically, break points or changes in grades shall be provided, such as tops of hills, bottom of ditches and gullies and high bank elevations. Ground elevations shall be to the closest one-tenth of a foot (0.1), all other elevations (roads, railroads, finished floors, utility lines drainage structures, monitoring wells, etc.) shall be to the closest one-hundredth of a foot (0.01).

13.3.2.1 Manholes, inlets, and all drainage structures. Indicate type, and show top, bottom, and all pipe invert elevations to the closest 0.01 foot. Provide the dimensions for all headwalls.

13.3.2.2 Provide top of curb and gutter elevations along existing pavements to the closest 0.01 foot. If necessary, provide a sketch to clearly show the type of curb and gutter.

13.3.2.3 Provide natural grade at building line, including spot elevations at all building corners (to the closest 0.01 foot for finished floors and paved areas), and to the closest 0.1 foot for natural ground.

13.4 Monitoring Wells: Each monitoring well within the topo limits shall be located in the field, plotted at the appropriate coordinate point on the topo sheet, and identified by number, coordinates (to the closest 1.0 foot), ground elevation (to the closest 0.1 foot), and the elevation of the

concrete pad or survey marker (if one is set in the pad) and the top of the casing (to the closest 0.01 foot). A tabulated list of the monitoring wells shall be prepared and submitted. The tabulation shall consist of the designated number of the well, the X and Y coordinates, and all of the required elevations. If wells need to be staked in the field prior to drilling, horizontal and vertical coordinates of staked locations shall be listed in the tabulation and shown on the map. Staked locations shall be designated as proposed monitoring wells.

13.5 Core Borings: The core borings required for the geotechnical investigation shall be located, and tied into the coordinate system (to the closest foot). Top of ground elevations (to the closest tenth of a foot) shall be obtained at each core boring. Each core boring shall then be plotted at the appropriate coordinate point on the topo sheet and identified by number, coordinates and ground elevation. A tabulated list of the core borings shall be prepared and submitted. The tabulation shall consist of the designated hole number, the X and Y coordinates, and the ground elevation for each boring. If borings need to be staked in the field prior to drilling, horizontal and vertical coordinates of staked locations shall be listed in the tabulation and shown on the map. Staked locations shall be designated as proposed core borings.

13.6 Field Notes: All field notes shall be recorded in hardbound field books. The leaves of the field books shall contain no less than 50 percent high grade rag stock (such as in K&E Field Book 82-0012). All notes shall be neatly entered and shall contain complete records of all field work done. Each notebook page used shall bear the date of the work recorded thereon and the first initials and last names of the personnel in the party shall be listed at the beginning of each days work. The first three pages of each book shall be used for an index. Every used page in the book shall be accounted for in the index.

13.7 Mapping Accuracy Requirements: All mapping shall meet the following horizontal and vertical accuracy requirements for a mapping scale of 1 inch = 30 feet with 1 foot contour intervals.

13.7.1 Contours: Ninety percent of the elevations determined from the contours of the topographic maps shall have an accuracy with respect to their true elevation of one-half of the contour interval or better, and the remaining ten percent of such elevations shall not be in error by more than one contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement of one-fortieth of an inch. (e.g. 30/40 = 0.75).

13.7.2 Coordinate Tic Marks: The plotted position of each coordinate tic mark shall not vary by more than one-hundredth of an inch at map scale from the true value.

13.7.3 Horizontal Control: Each horizontal control point shall be plotted to an accuracy of one-hundredth of an inch at map scale of its true position as expressed by the coordinates published for the point. Elevations shall be shown if available.

13.7.4 Planimetric Features: Ninety percent of all planimetric features which are well defined on the photographs shall be plotted so that their position on the finished maps is accurate to within at least one-fortieth of an inch at map scale of their true coordinate position, and none of the features shall be misplaced on the finished map by more than one-twentieth of an inch from their true coordinate position.

13.7.5 Spot Elevations: Ninety percent of all spot elevations placed on the maps shall have an accuracy of at least one-fourth the contour interval, and the remaining 10 percent shall not be in error by more than one-half the contour interval.

14.0 DIGITAL DATA REQUIREMENTS: The type of software/hardware used for this contract will be determined by the contractor. However, Intergraph CADD and ESRI GIS software are compatible with the COR software.

14.1 Sheet Layout: A data window approximately 26" x 28" shall be utilized on each sheet. Sheets shall match adjoining sheets along the data window lines. A sheet index comprised of main roads, rivers and features overlaid with the data window grid and sheet numbers shall be on each sheet in the right hand margin area. The appropriate sheet shall be cross-hatched to indicate location.

14.2 Legend: A legend in a separate level shall be shown on each sheet in the right hand margin area. Symbols used for the mapping shall be shown and explained by text.

14.3 Notations: Notes concerning the date of photography or data collection, state plane zone with combination factor used, source of data, national map accuracy certification, source of utility information and any other pertinent statements shall be shown in the right hand margin area.

15.0 DELIVERABLE ITEMS: Items and data to be delivered to the U.S. Army Corps of Engineers - Omaha District are as follows:

15.1 Originals of all field books, sketches and computations: All of these items shall be suitably bound, and clearly marked and identified.

15.2 Control Listing:. A tabulated list of all control points showing the adjusted coordinates and elevations (to the closest one hundredth of a foot) established and/or used for this survey with descriptions.

15.3 Marker Documentation Sheets for established primary control: See p. 6-5 of EM 1110-1-1002 for example.

15.4 Wells and Borings: Tabulated lists of all monitoring wells, soil borings, test pits, etc. found or staked, showing horizontal coordinates to the closest 1.0 foot and all of the required elevations to the closest 0.1 foot or 0.01 foot as applicable.

15.5 Scale: All maps shall be plotted at a scale of 1 inch = 30 feet on 30 inch by 42 inch vellum sheets similar to (exhibit "C"). All drawings shall be generated by the CADD system. One original copy of each final drawing shall be delivered to the Omaha District. Sheets will be separate and trimmed.

15.6 CADD Files: The means for translation to Intergraph CADD must be supplied or currently available to the Omaha District. Surface files in .TTN format shall also be delivered if available. If .TTN format is not available then an ASCII file of coordinate points, break lines, etc. used to generate contours shall be provided. Data files shall be written to 9 track, 1600 bpi or 6250 bpi density tapes written with VAX backup or copy command or ASCII equivalent. If the data in separate files can be fit onto no more than three 5-1/4 inch 1.2 Mb diskettes then, it may be delivered on diskette rather than tape.

16.0 GEOGRAPHIC INFORMATION SYSTEM TYPE SOFTWARE:

16.1 General: The GIS will be used to assist in lot inventory and supplement replacement of items removed from lot. The lot inventory will include but not be limited to plants, trees, landscaping, etc. The software used will be determined by the contractor. However, the software must be able to do the following functions:

(a) Calculate volume of soil to be removed.

(b) Overlay lot lines with associated address and ownership information.

(c) Generate 8-1/2 x 11" sheet of every lot with planimetric field data. Lot inventory will be dimensioned on these maps. Include appropriate grid and scale on each map. Scale may vary depending on size and shape of the lot.

(d) The contractor may digitize the lot inventory. To facilitate calculation of replacement costs and reduce paper usage. (optional)

17.0 Items Relating to the Aerial Mission to be Delivered:

(a) The original sets of negatives.

(b) One (1) complete set of contact prints.

(c) One (1) complete set of diapositives providing stereo coverage of the project areas.

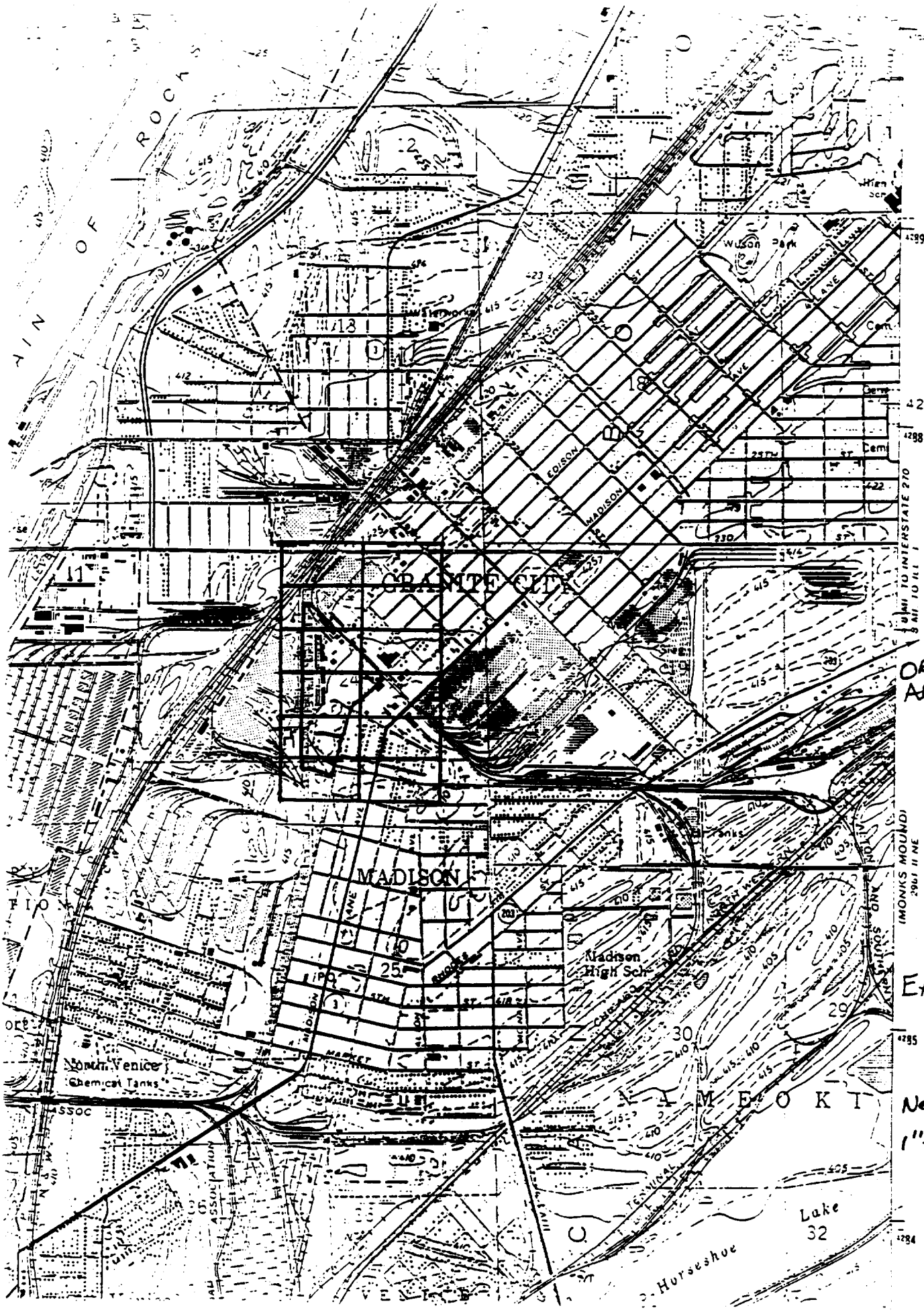
(d) One (1) copy of the current USGS calibration sheet on the camera used for this project.

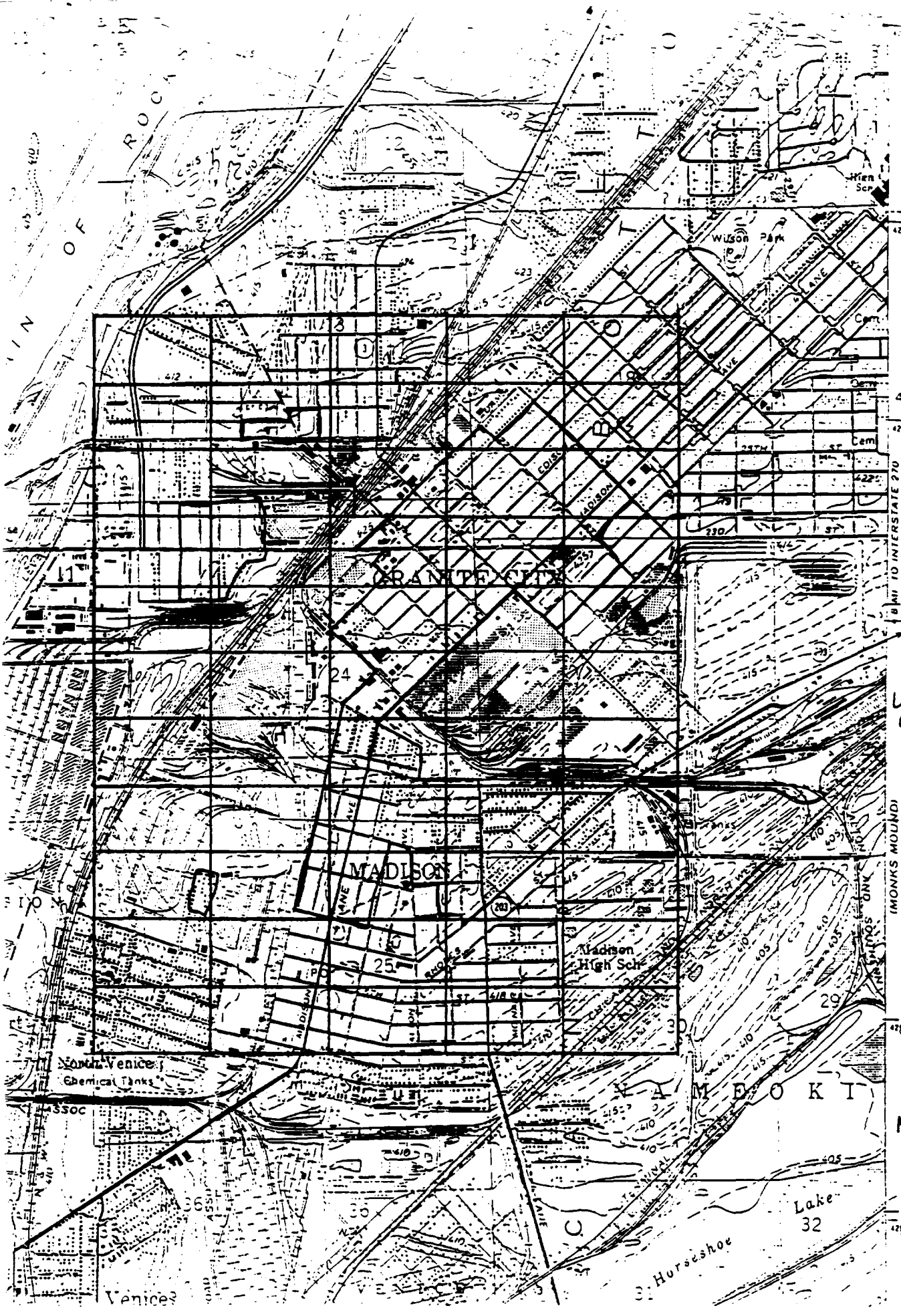
(e) Photo index(s) and index negative(s).

18.0 PLACE OF DELIVERY:

District Engineer
U.S. Army Engineer District, Omaha
Attn: Surveys and Mapping Section
215 North 17th Street
Omaha, Nebraska 68102-4910

19.0 DATE OF DELIVERY: Date of delivery shall not exceed 60 days from the date that the mission was flown.


GRANITE CITY
MADISON
Madison High Sch
North Venice
Chemical Tanks
Lake
32
42'30"
ORANGE AREA
Exhibit A
Neg Scale
1"= 200'


GRANITE CITY
MADISON
Madison High Sch
Wilson Park
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42'30"
4288
4289
4285
4284
INTERSTATE 270
MONKS MOUND
Yellow AREAS
Exhibit
Neg Scale
1" = 300'

EM 1110-1-1002
14 September 1990

US Army Corps
of Engineers

ENGINEERING AND DESIGN

Survey Markers and Monumentation

ENGINEER MANUAL

DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

EM 1110-1-1002

CECW-EP

Engineer Manual
No. 1110-1-1002

14 September 1990

Engineering and Design
SURVEY MARKERS AND MONUMENTATION

1. Purpose. This manual establishes criteria and presents guidance for monumentation during various stages of civil and military projects.

2. Applicability. This manual applies to all field operating activities having civil works and military responsibilities.

3. Accompanying Guide Specification. To facilitate contracting for monumentation, accompanying guide specifications have also been developed. This manual is designed to be used in conjunction with the accompanying guide specifications as an aid in contracting for monumentation.

FOR THE COMMANDER:

ALBERT J. GENETTI, JR.
Colonel, Corps of Engineers
Chief of Staff

DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

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Table of Contents

CHAPTER 1

INTRODUCTION

1-1. Purpose. This manual establishes criteria and presents guidance on monumentation installation and documentation for all types of surveys required during the various stages of civil and military projects. The manual is intended to be a guide; however, when the standard Corps monuments are used, they shall be selected and constructed as defined in this manual.

1-2. Applicability. This manual applies to all Corps of Engineers field operating activities.

1-3. Reference. Specifications on naming criteria, standard installation procedures, and accuracy classifications were adopted in part from the National Geodetic Survey (NGS).

1-4. Background. Stable monuments are required for both horizontal and vertical control. Monuments and their stability are integral parts of the accuracy of each survey project. Inaccurate survey control monumentation can contribute to costly errors in all phases of project design and development. Therefore, the purpose of this manual is to establish criteria and present guidance that will insure stable monumentation throughout design, construction, and subsequent maintenance of each Corps project.

1-5. Scope of Manual. This manual provides naming criteria, standard installation procedures, and associated surveying accuracies for horizontal and vertical control and boundary survey markers and monumentation for standard Corps monuments. It should be used as a guide in planning surveys and marker and/or monument installation and identification. The type of marker and/or monument selected for each survey should be tailored to meet the minimum accuracy requirements for the individual project. However, selection should be done within the stated criteria where feasible and practicable, using the guidance provided herein. The accuracy classification of each survey monument is dependent upon the site foundation conditions and the type of monument installation used. All standard Corps monuments as defined herein shall be installed in accordance with this manual. The term "marks" shall be used throughout this manual when referring to both permanent monuments and temporary markers. The term "bench mark" refers to a mark whose elevation is known. Monuments and markers are further defined in paragraphs 1-7 and 1-8.

1-6. Development of a Survey Monumentation Comprehensive Plan. In the earliest phase of project development a survey monumentation plan shall be developed. This plan shall consider monuments required for the life of each project, i.e., planning, acquisition, design, construction, operation, and maintenance. This plan will eliminate surveys performed using different survey

control accuracies and provide a common base for all surveys for each project.

1-7. Permanent Monuments. Permanent monuments shall be defined as monuments that are set in relatively stable material or in a structure for the purpose of preserving the location of either a horizontal control station, the elevation of a point above an adopted datum (bench mark), or the location and/or elevation of any point of special significance when its preservation is required permanently or for longer than 2 years. All monument types shown in the tables in this engineering manual are considered to be permanent.

1-8. Temporary Markers. Temporary markers shall be defined in the same manner as permanent monuments except that preservation is only required for a period of 2 years or less. Temporary markers shall consist of a 1- by 2-inch or larger wooden hub with adjacent guard stakes, a copper nail and washer, P-K nail, or other temporary spike set in relatively stable in situ material. Markers established on structures less than 5 years old shall also be considered temporary.

1-9. Public Relations. The purpose of the Federal government and its contractors is to serve the public. To fulfill this charge, it is imperative to gain the understanding and maintain the goodwill of the public. With these considerations in mind, always obtain the permission of the landowner when setting marks on private property. Responsible officials must also be consulted when a prospective site is located on public or corporate land. If approached in a polite and tactful manner, a hesitant individual may often be persuaded to allow installation of a mark at the desired site. Most citizens may be influenced to take personal interest in having a monument carrying the U.S. Army Corps of Engineers (USACE) designation on their property. To help encourage an individual to cooperate, explain the purpose of these marks, the need for the stability and durability of marks, and the expense involved in replacing them. Under no circumstances shall a mark be installed on an unwilling property owner's land that could provoke hostility toward the Federal government and its contractors.

1-10. Metrics. The use of both the metric and English systems of measurement in this manual is predicated on the common use of both systems by the surveying and mapping professions; i.e., water depths are usually measured in feet, and distances are usually measured in meters as determined by the equipment manufacturers.

1-11. Brand Names. The citation in this report of brand names of commercially available products does not constitute official endorsement or approval of the use of such products.

CHAPTER 2

SITE SELECTION

2-1. General. The most effective precaution that can be taken to assure a mark's stability and survival is to choose an appropriate location. Since there are a wide variety of possible situations that may be encountered when setting a mark, it is virtually impossible to address them all in this manual. Therefore, the ultimate selection of a site is necessarily left to the discretion of the mark setter; however, it is imperative that good judgment be exercised. The resultant accuracy of any survey will be determined in part by the stability of the marks. A mark setter exercising good judgment is defined as an individual who thoroughly evaluates the security, utility, stability, environment, and safety of the mark and its site before establishing the marks. The most important site selection parameters are discussed in the following sections.

2-2. Security. Foremost on the list of evaluation considerations is the mark's susceptibility to damage or destruction. In view of the great expense involved in establishing a mark and the data associated with it, time spent in preservation is worthwhile. It is necessary to anticipate any construction that might occur at the proposed mark location. Is the site selected for marks in the path of a future highway, waterway, ditch, or pipeline? Will an adjacent shopping center or parking lot be expanded in the foreseeable future? Is the prospective mark site near a potentially active mine or quarry? Highway maintenance often involves the widening of the road surface and the straightening of curves. Marks set near the edge of the right-of-way and on the outside of a curve increase their chances for survival. Conversely, the outside of a river bend is not an appropriate site for marks because the effects of erosion may lead to undercuts in the bank. The effects of undercutting may also occur on shoreline scarps where stormy waters slowly erode the embankment. Floodplains should be avoided when otherwise comparable sites are available. Marks located in floodplains may be buried in sediment or washed out due to erosion. Often, sites may be located in areas that provide natural protection for the mark. Locations near the edge of the right-of-way, well away from a highway surface, provide protection for marks. Property fence lines and utility poles usually remain in place for many years and afford good protection for marks. Structures that are of themselves not suitable for mark settings prevent vehicles and equipment from damaging marks that are set adjacent to them. In addition, from a standpoint of survival, Federal, state and local public areas, as well as private property and cemeteries, provide excellent sites for marks.

2-3. Utility. Accessibility of the marks by users should be evaluated in selecting the mark's site. If the mark cannot be found or if the site cannot be conveniently occupied, its worth

is questionable. Are there nearby objects that can be used to reference the mark? Are these objects fairly permanent? Can suitable measurements define a precise point where a hidden mark can be found? To enable the mark setter to establish a mark where its position can be accurately described, familiarity with referencing techniques is required. Marks are usually described in the following manner: Directions are given to the general area in which the mark is located. Normally, this puts the individual within 100 meters (328 feet) of the mark. Then the mark is located by distances and directions from prominent reference objects. These distances and directions establish lines of position (LOP). The prominent objects are referred to here as "origins." At least two LOPs are required to define a point, but additional LOPs are desired in case some reference objects are destroyed. Also, the more nearly perpendicular the angle at which LOPs intersect, the more accurately a position may be determined and the easier it will be to locate the mark. Consideration should be given to the ease with which the location of a mark may be established from reference measurements. It is important that this information be included on the mark documentation as discussed in paragraph 6-1.

2-4. Stability. All marks are subject to the effects of geologic and soil activity. Vertical control marks (bench marks) are particularly vulnerable because this activity results in vertical movements much more so than horizontal motion. Therefore, the following environmental effects should be evaluated when considering a mark site.

a. Advantageous Topographic Features. Crests of hills are good places to set bench marks for three reasons. First, the problem of slope instability is eliminated. Even though the neighboring hillside might be sliding, the summit will generally remain stable. Second, frost heave is less likely with the increased separation from the water table. And third, the consistency of the soil will tend to be more firm.

b. Effects of Soil Grain Size. Whenever soil types can be ascertained, it is preferable to choose a site with coarse-grained soils rather than one with fine-grained soils. Most of the problems associated with soil movements are attributable to the fine particles it contains. The fraction of grain sizes less than 0.02 millimeter governs whether or not a soil is frost susceptible. Soils susceptible to high volume change due to variation in moisture content are normally clays, which are very fine-grained. In addition, poorly drained clays provide environments conducive to corrosion. If an alternative is available, avoid sites with fine-grained soils, especially clays.

c. Effects of Vegetation. The presence of vegetation, particularly trees, has marked influence on the stability of the upper layers of a soil mass. Trees, underbrush, grass, and moss act as insulation, reducing the depth of the active frost zone and thus reducing frost heave. However, the problems associated

with expansive soils (clays) are aggravated by vegetation. In seasons of abundant rainfall, vegetation exerts very little influence on soil volume change. However, when the weather is dry and there is little free water available in the soil, trees and other plants will draw more water out of the soil than is normally lost through evaporation. The result is a lowering of the water table and even greater soil shrinkage. With trees, this effect occurs within a radial distance from the trees roughly equal to their heights. Areas covered with thick vegetation should be avoided even where expansive soils do not exist. Dense vegetation may conceal a monument, making it of much less value than one that is open to view. Marks should not be located near lone trees due to potential disturbances from growing roots.

d. Geological Effects. It is generally not feasible to determine the nature and extent of subsurface geological activity. Nevertheless, it is an important consideration that should never be overlooked when the information or a means of obtaining the information is available. Detailed geological data are very important in locating pockets of unstable ground within a generally stable area. Caverns and underground mines, as well as water and oil-bearing strata subject to pumping, are especially prone to cause significant subsidence. Marks established strictly for geodetic control should not be set in these areas. Whenever possible, sound bedrock should be used for a mark setting. However, it is often difficult to determine whether or not an outcrop is indeed sound bedrock, especially when the decision is based mainly on visual evidence obtained from an exposed portion of the formation. Where a large portion of the outcrop is exposed, try to insure that the section of rock in which the mark will be set is essentially intact with the rest of the outcrop. Carefully examine the surface of the bedrock to insure that it is solid and not in a state of deterioration. The margin of weathered rock can be surprisingly thick. If its surface has begun to crumble or contains deep fissures in close proximity, the outcrop is probably unsound and should not be used as a mark site. In this case, another type of mark or another location may improve stability. Some sedimentary rock, such as montmorillonite, contains detrimental clay minerals. Geological maps or expert advise may help determine if a sedimentary outcrop is expansive and therefore unsuitable as a mark setting. In this case, a site should be located in a structure or another rock outcrop. If this situation is not practical, a rod-type mark should be used. The effects of expansive bedrock due to variations in moisture content is not a problem if there is a sufficient overburden.

e. Man-made Structures. Since structures are subject to movements, fixing a mark on a structure does not assure that it will be a good geodetic control point. Before setting a mark it should be determined whether or not the structure will be as stable as a Type A rod mark (see Table 3-1). If not, use a Type B (see Table 3-1) or any other suitable rod mark. The stability of a large structure may be related to a Type B rod

mark by comparing the depth of the structure's foundation to the required depth of the rod mark sleeve. In addition, the structure should be a multistory design constructed of concrete, masonry, or steel. The Type B rod mark sleeve is set to a depth below that affected by expansive soils and frost heave. For a structure to be of comparable stability, the foundation need not be as deep as the rod mark sleeve. This is attributed to the weight of the structure, which can resist some of the expansive forces exerted by the soil. Also, the structure itself will have a shielding effect on the soil below, making conditions such as temperature and moisture content less variable. If the foundation of a structure is at least a quarter of the specified sleeve depth of a Type B rod mark, the structure is considered stable. Small structures, such as concrete culverts, platforms, retaining walls, bridges, etc., shall never be used for permanent monumentation. Very large bridges can be used if the structural member in which the monument will be set rests directly on bedrock, deep piles, or piers. Most structures are expected to settle both during and after construction. A structure less than 5 years old shall not be considered for vertical control marks unless its foundation is on bedrock. In general, a structure with a long life expectancy should be selected. Modern buildings will probably remain undisturbed for a long time. Older buildings of historical significance may provide a good site for a permanent monument. Caution should be taken to assure that the monument is placed in a location that is an integral part of the structure's foundation or fixed rigidly to it. Placing a permanent monument on an appendage, such as steps entering a building, is unacceptable unless the appendage has its own foundation of sufficient depth. Avoid sites that might be damaged or covered during any additional construction on or near the structure.

f. Miscellaneous Areas to Avoid. Sites near water reservoirs and large rivers, where the water level is variable, can rise and fall due to rebound and compression of the soil. This type of movement can have a significant effect on the precision of geodetic measurements. If possible, marks should be established a few hundred meters from the boundaries of these sources of ground activity. Permafrost has a stabilizing effect on marks anchored to a sufficient depth. Significant expansion and contraction of frozen ground due to temperature variation can occur to a depth of about 10 meters (33 feet). A permanent monument anchored below this depth can be expected to be quite stable. In regions where permafrost normally exists near the surface, sources of thawing can keep the ground in an unfrozen condition to a greater depth than expected. Any body of water, such as a pond, lake, or river, will have this effect. Other influential thawing sources include buildings, roads, pipelines; in short, any mark of civilization.

2-5. Corrosive Environment. The rate at which a material will corrode or deteriorate is affected by its environment. There are two conditions necessary for corrosion to occur. First, the metal being corroded must be in contact with an electrolyte or a

liquid capable of conducting electric current. Electrolyte composition may vary widely, ranging from a minute amount of nearly pure water formed by condensation to seawater. Secondly, there must be a dissimilarity in two areas of the surfaces being corroded. This could result from the presence of strains or inclusions in an alloy, the contact of dissimilar metals, or a variety of possibilities between these two extremes. The most important environmental factors governing the corrosive character of a soil are the degree of aeration and the presence of any water-soluble salts. Aeration is an important soil characteristic because many metals need exposure to oxygen in order to form a dense, tough layer of metallic oxide on their surfaces. The oxide coating prevents further corrosion by isolating the remaining metal from any electrolytes. Aluminum and steel protect themselves in this manner. Water-soluble salts have an influence on corrosion in two ways. First, the ions that form when salts dissolve improve the capability of the electrolyte to carry current. The greater the ability of the electrolyte to carry current, the faster corrosion will occur. Water with dissolved salts is a better electrolyte than pure water. A second effect of water-soluble salts is the influence they have on the formation of the dense, tough protective oxide layer that forms on the surface of certain metals. Rod marks will at times unavoidably be placed in corrosive soils. As a protective measure, rod marks placed in corrosive soils should be Type B made of Type 316 stainless steel. This material is more resistant to corrosion than other affordable alloys in nearly all environments. Nonetheless, steps may be taken to increase its life span. Stainless steel is most susceptible to corrosion in poorly aerated environments and those in which chlorides are present. Well-aerated soils are generally recognized by their red, yellow, or brown colors resulting from the oxidation of iron compounds commonly found in soils. Sites with this type of soil characteristic provide a good location for permanent monument setting. Poorly aerated soils are usually gray in color due to the lack of sufficient oxygen to oxidize the iron compounds. Soils of this type may also be identified by their poor drainage characteristics. Avoid areas where there is a high concentration of chlorides. Rod marks set along highways, where heavy salting might be done in winter, should be located at least 10 meters (33 feet) from the road surface. In general, setting marks along the edge of the right-of-way is a good practice. Although it will sometimes be impossible, due to project requirements, try to avoid saltwater shorelines. When the purpose of a project is to provide shoreline control, stay off the beach when possible. Another good indication of the corrosive character of a soil may be obtained if one has the capability to measure soil resistivity. The more resistant a soil, the poorer the electrolyte and, consequently, the less corrosive it will be.

2-6. Safety. If a mark extends below ground level, there is a chance of encountering underground cables or pipes during installation. This is especially a concern when drilling a hole for marks requiring sleeves or casings. This situation is more

critical in urban areas than in rural areas. Evidence of underground utility lines often can be observed at the surface. Water lines are marked by valve boxes at most street intersections. Avoiding the area between valve boxes will decrease the chances of hitting a pipe. Fire hydrants are a good indicator of the location of water mains. Hydrants usually are placed within a meter (40 inches) of the line and to the side away from the street centerline. Most water and sewer lines lie under the road surface, but some are placed adjacent to it. Therefore, avoid the area between the street and the sidewalk. Telephone and electrical cables are normally laid from 0.5 to 1 meter (1.6 to 3.3 feet) below the surface. Housing developments built in the 1960s and later are much more likely to have underground cables than those built before that time. The absence of telephone and power poles is conclusive evidence that there are underground cables in the area. However, the presence of utility poles does not necessarily indicate the lack of underground cables. Buried telephone lines usually run directly between junction box pedestals or between telephone poles. Electrical cables may run adjacent to telephone lines. When an electric appliance, such as an air conditioning unit or floodlight, is located apart from other structures, an underground cable to it would probably run directly from a metering device. Gas lines are generally harder to detect. Meters and valves are helpful in locating buried gas lines if they are not situated too far apart. As with telephone cable pedestals, do not drill or drive monuments in an area between visible gas devices. If circumstances permit, the best way to avoid problems is to contact the local metropolitan utilities commission. A utility locator service will locate underground utilities by painting the ground. Do not drill or drive monuments within 60 centimeters (2 feet) of either side of the painted line. In addition, it is wise to develop a habit of looking for "Buried Cable" signs. In conclusion, if other considerations in the site selection will allow, monuments may be set near utility poles, for greater security, avoiding the areas between adjacent poles.

2-7. Satellite Visibility. In addition to permanence, utility, and stability, satellite visibility must also be considered when selecting sites for monumentation for Global Positioning System (GPS) type surveying. The proximity of existing bench marks should also be considered when performing dynamic surveying. Sites that provide maximum visibility above the horizon, plus 15 degrees, should be selected. Any obstructions above 15 degrees will potentially block satellite signals. The site ideally should have visibility in all directions above 15 degrees; however, in some locations at specific times, an obstruction in one or possibly two directions may not affect the ability to use the site for GPS surveying. Existing bench marks should be utilized as often as possible as GPS monuments, or new marks should be located as close as possible to known vertical control. For maximum utility and economical use, maximum effort should be made to locate all GPS type monuments within 100 feet of easy access to vehicular ground transportation.

2-8. Cost Comparison. Experience has shown that the earth's crustal movement is dynamic in both the vertical and horizontal directions to various degrees at different sites. This is caused by a combination of several factors such as regional crustal plate movements, removal of subsurface fluids, soil shrinking and swelling, soil freezing and thawing, growth of vegetation, construction of new structures, and settlement of old structures. When developing a monumentation plan, a comparison should be made between the cost of additional monument installation and additional leveling to more stable areas that require less costly monuments. The average cost of second-order and third-order leveling per mile is presently $800 and $480, respectively. The average cost to install a Type A rod monument to 50 feet of depth is presently $280. Additional depth beyond 50 feet will average $3 per foot. In developing the cost comparison, future uses of the mark must be considered; e.g., if marks will be used frequently, there will be an additional future cost of leveling in locations where marks are constructed away from the immediate site where they are needed. In most cases, the cost of repeated or additional leveling will far exceed the extra cost required to install the most stable monument at the site where needed.

CHAPTER 3

VERTICAL CONTROL - BENCH MARKS

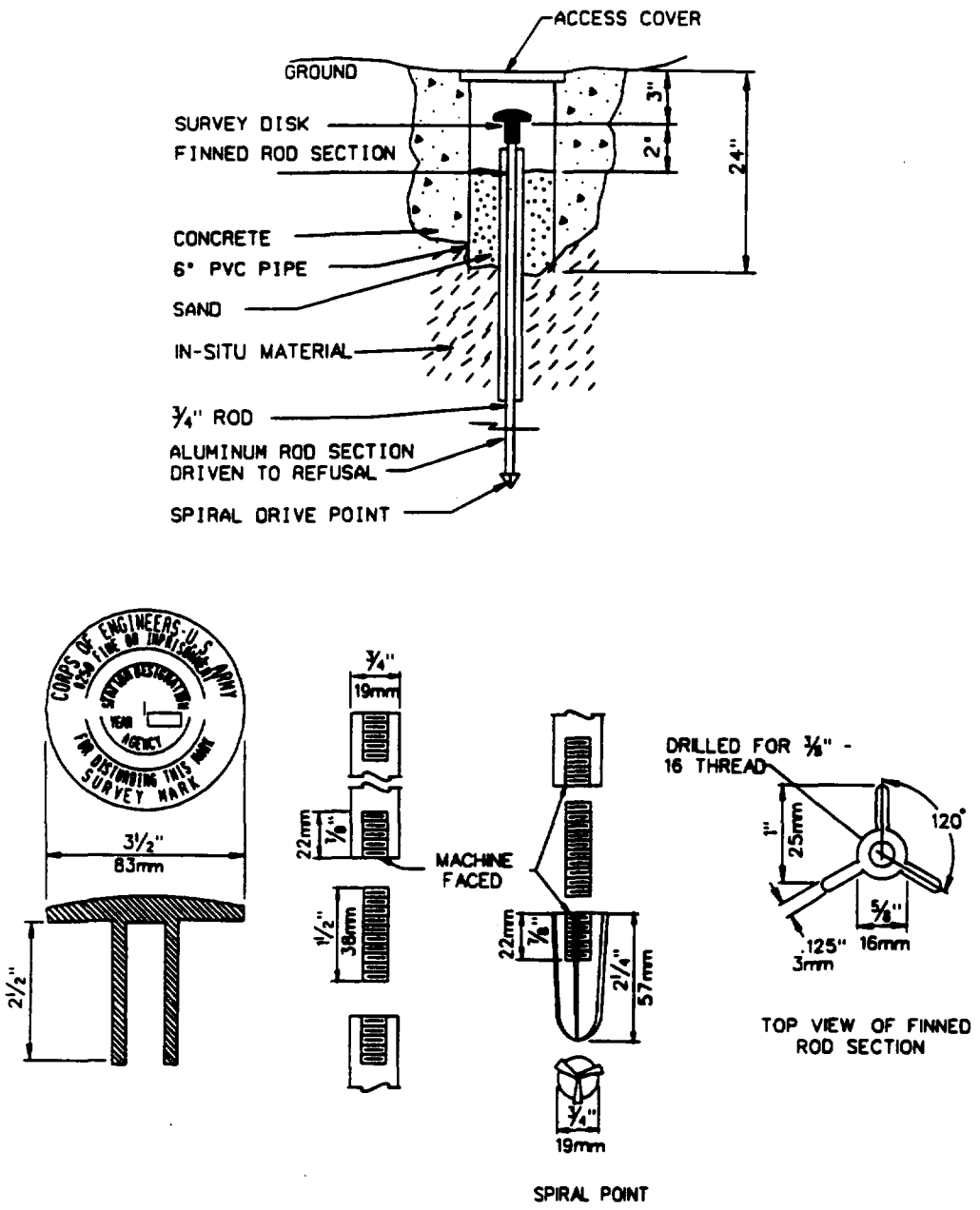
3-1. Selection of Monument Type Based on Local Site Conditions. Types of marks to be used for vertical control are a function of the order of accuracy of the survey, the intended use of the data collected, and the site conditions. The types of monuments that can be used for vertical control, depending on local site conditions, are identified in Table 3-1. Construction and installation details are discussed in the following paragraphs.

Table 3-1

Site Conditions and Monument Types for Vertical Control

Site Conditions	Order of Accuracy			
	High	1	2	3
Rock outcrops, large boulders, bedrock concrete structures (more than 5 years old)	C	C	C	C
Granular soils (sand and gravel)	B	A,B	A	F,G
Glaciated soils (till)	B	A,B	A	F,G
Fine-grained soils (silts and clays with high bearing strengths)	B	A,B	A	F,G
Fine-grained soils (silts and clays with low bearing strengths)	B	A,B	A	A
Construction fill (disturbed earth)	B	A,B	A	A
Permafrost	E	E	D,E	D
Marsh	B	B	B	A
Subsidence area	B	B	B	A

a. Type A - Deep Rod - Aluminum with Finned Section. Type A rod marks (Figure 3-1) should be used when sound bedrock or substantially stable structures are not available. The mark is provided with extra horizontal stability required for three-dimensional surveys, which makes the mark a suitable GPS mark. This mark should not be used in highly corrosive environments.



USE FOR VERTICAL, HORIZONTAL AND BOUNDARY CONTROL

Figure 3-1. Type A monument - deep rod - 3-foot finned section

Table 3-1 indicates the recommended usage for the Type A monument.

b. Type B - Deep Rod - Stainless Steel with Sleeve. Type B rod marks (Figure 3-2) should also be used when sound bedrock or substantially stable structures are not available. Type B rod marks shall always be used in highly corrosive environments. Since this mark is also provided with horizontal stability, it may also be used as a three-dimensional monument.

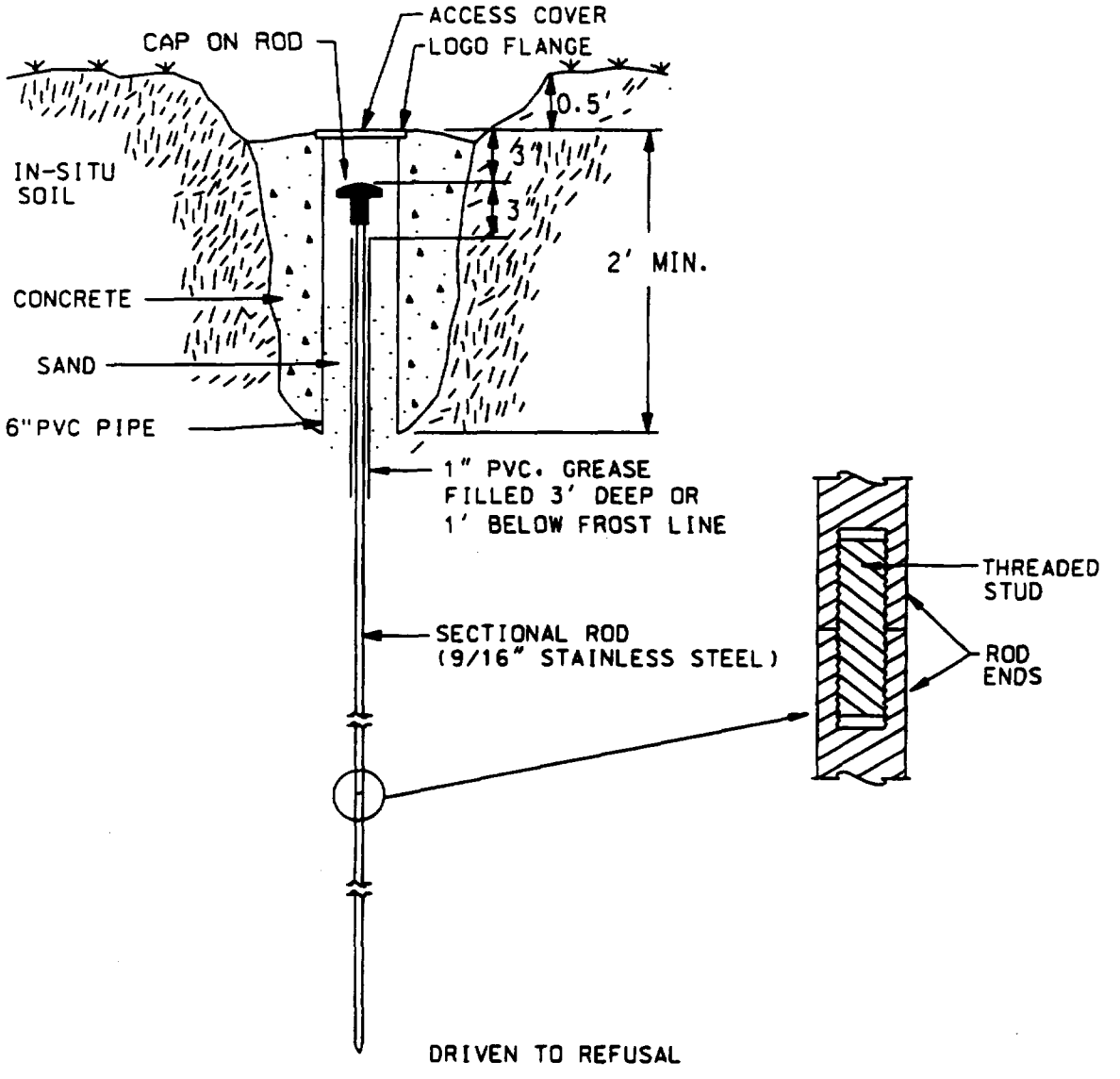
c. Type C - Disk in Bedrock or Concrete Structures. Sound bedrock is the most desirable location for a bench mark as illustrated by Type C monument (Figure 3-3); it provides the most stable setting in terms of both underground activity and potential disturbances. Always use bedrock when a suitable outcrop exists. As a rule of thumb, a bedrock outcrop is considered acceptable if the distance between adjacent joints and fissures is greater than 1 meter (40 inches).

d. Type D - Deep Rod - Frost Resistant (Anchored in Permafrost). Changes in bench mark position caused by frost heave can occur where soil freezes and thaws annually. This problem is most severe where annual frost penetrates deeply. Figure 3-4 illustrates the maximum depth of frost in meters for the United States. Significant subsurface movement of soil in permafrost areas can occur to depths of up to 9 meters (30 feet), and conventional bench marks can be moved several inches due to frost heave in winter and subsequent settlement during summer thaws. Type D monuments are frost-resistant bench marks designed to be anchored in permafrost (Figure 3-5).

e. Type E - Deep Rod - Frost Resistant (Anchored Below Permafrost). The primary difference between the Type E rod and the Type D rod is that the Type E will be anchored below permafrost as illustrated in Figure 3-6. Type E monuments shall be selected when the greatest monument stability is required in a permafrost area.

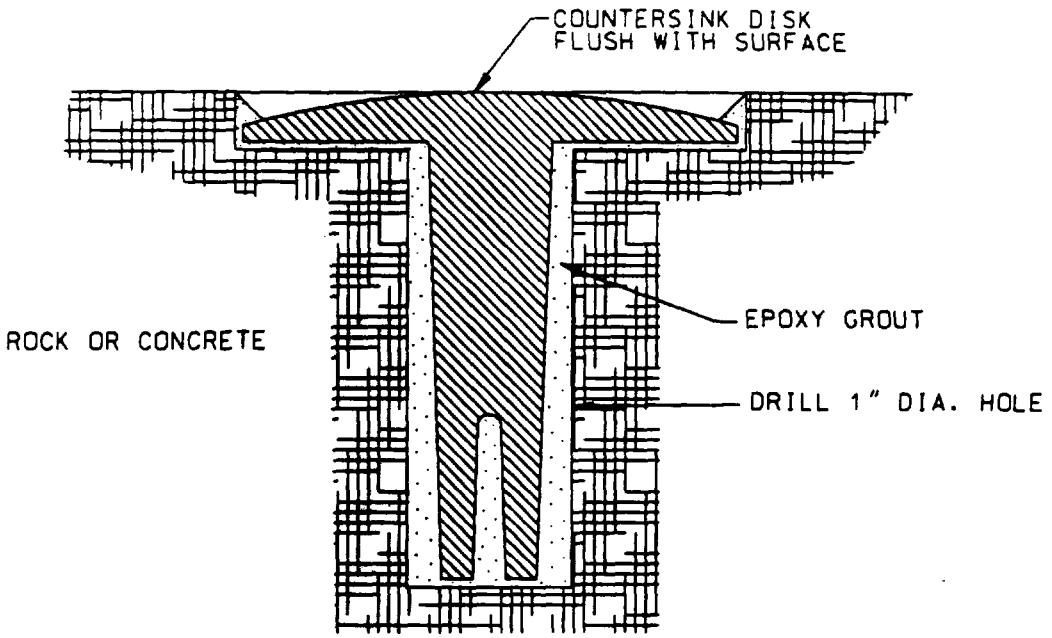
f. Type F - Shallow Rod - Finned, No Casing. The Type F shallow rod mark may be used in granular soils such as sands and gravels, glaciated soils or fine-grained soils such as silts and clays with high bearing strengths. The Type F rod mark is suitable for third order accuracy. If higher order accuracy is needed, then the Type A or Type B rod mark should be selected. The Type F rod mark is illustrated in Figure 3-7. Type F monuments shall also be used for reference and azimuth marks.

g. Type G - Disk in 3/4-inch Pipe or on Rebar. The Type G rod mark is selected for the same sites as the Type F mark; the primary difference is construction and installation details. The Type G rod mark is illustrated in Figure 3-8. Type G monuments shall be selected in lieu of Type F monuments when circumstances will allow the construction of the Type G monument.



USE FOR VERTICAL AND HORIZONTAL CONTROL

Figure 3-2. Type B monument - deep rod - stainless steel with sleeve



USE FOR VERTICAL, HORIZONTAL AND BOUNDARY CONTROL

Figure 3-3. Type C monument - disk in rock or precast concrete

h. Deep Bench Marks in Clay. When the site geology is known to consist of sensitive clays, the Type B rod mark should be used. The PVC sleeve should extend through the sensitive clay layer. The anchored section should be driven to refusal. When the site geology is known to consist of lacustrine clays, the Type B rod mark should be used. The PVC sleeve should extend through the highly desiccated soil.

i. Natural or Ready-Made Bench Marks. Occasionally, a natural or ready-made bench mark setting, which cannot accommodate a brass disk, will exist that would be more stable than a rod mark.

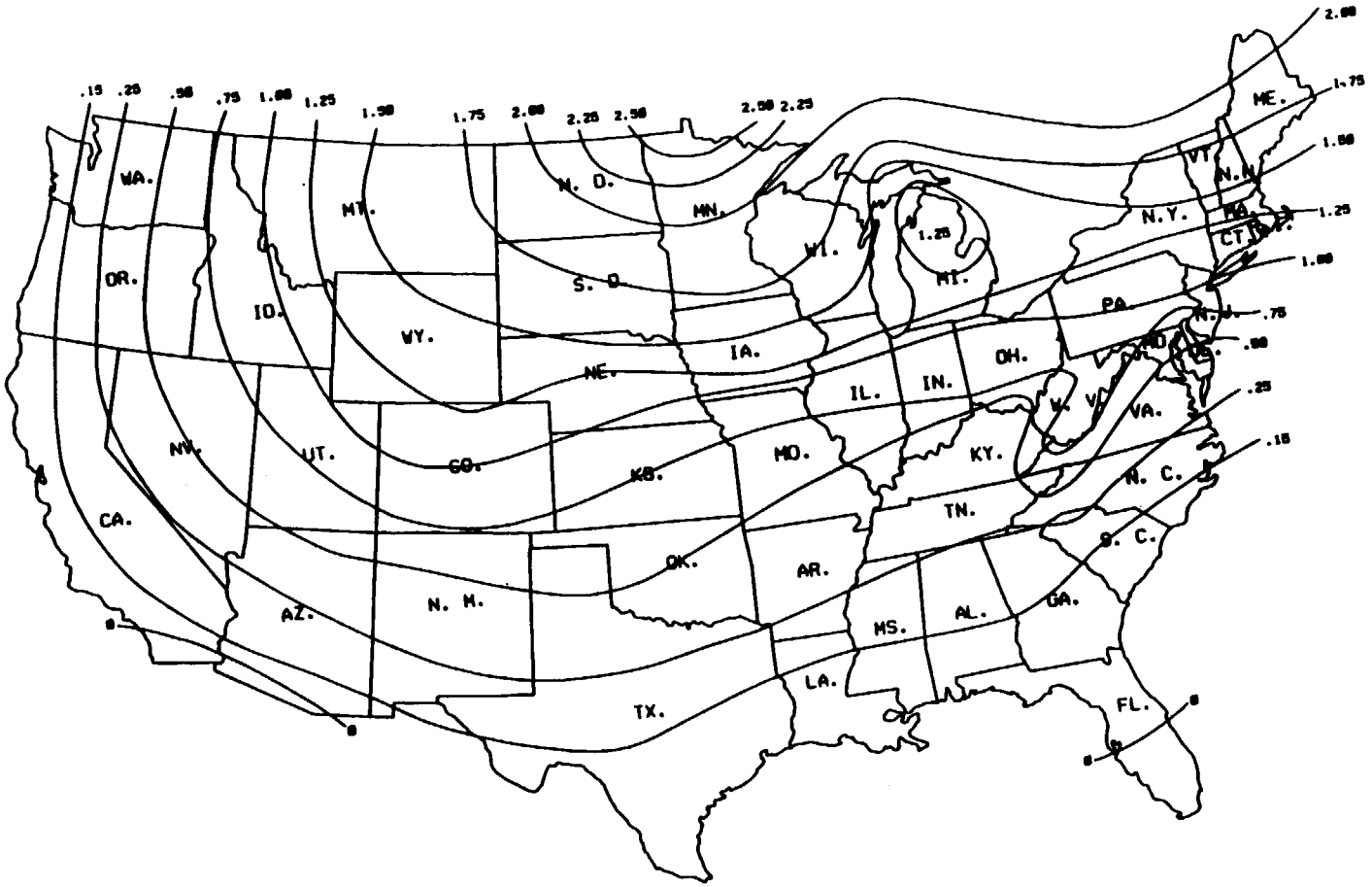
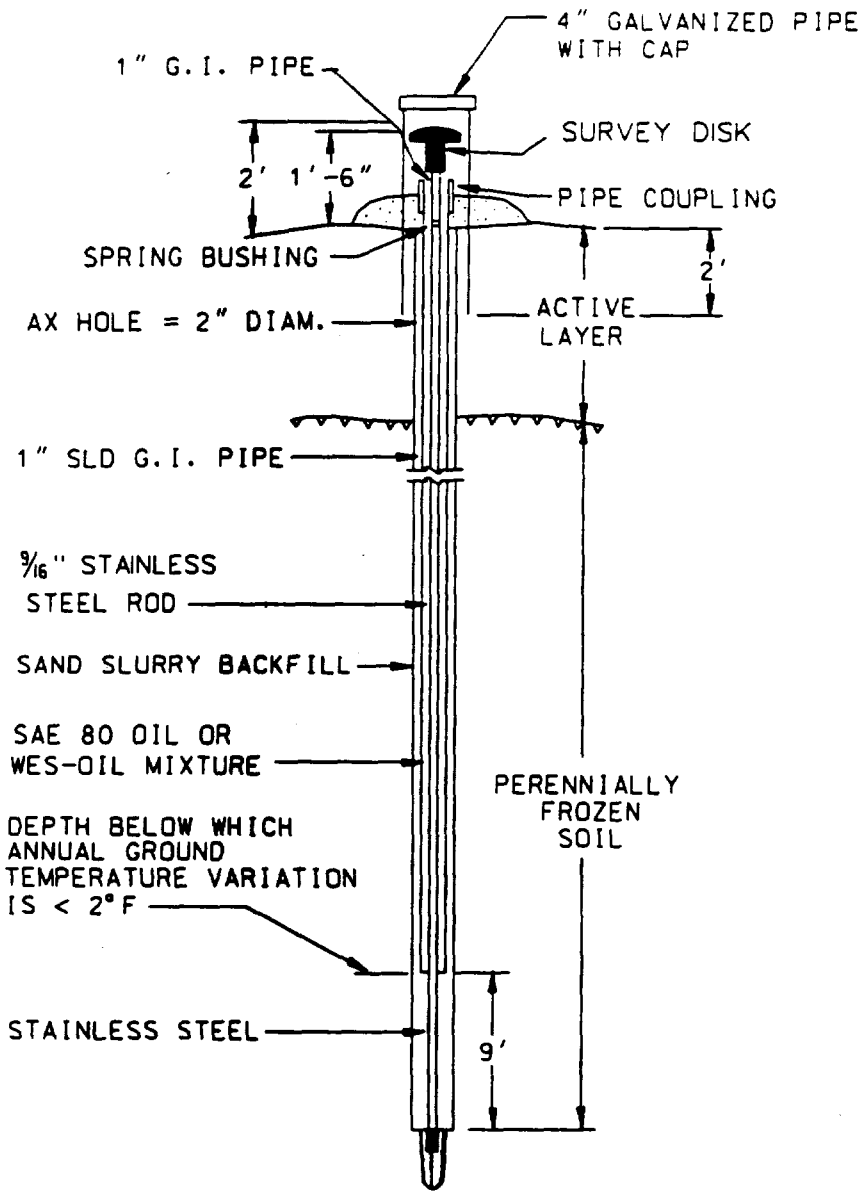


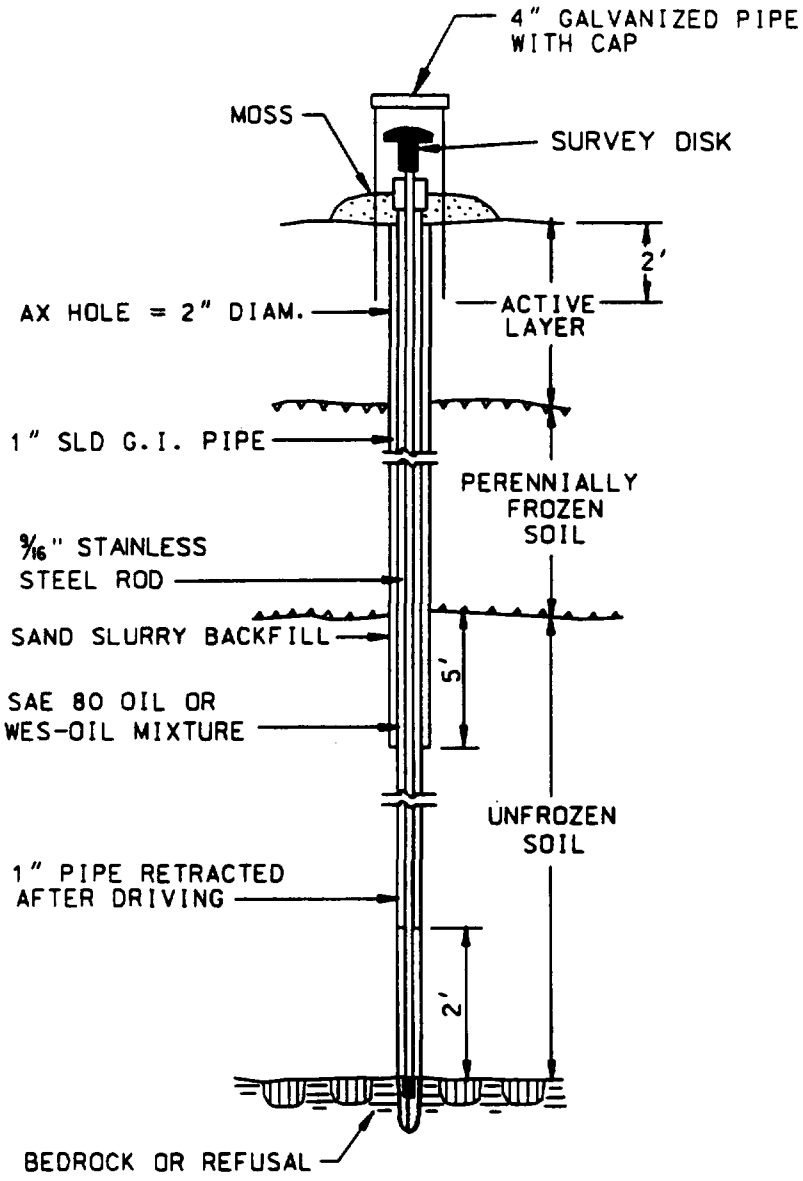
Figure 3-4. Maximum depth of frost (meters)



ANCHORAGE IN PERMAFROST

USE FOR VERTICAL AND HORIZONTAL CONTROL

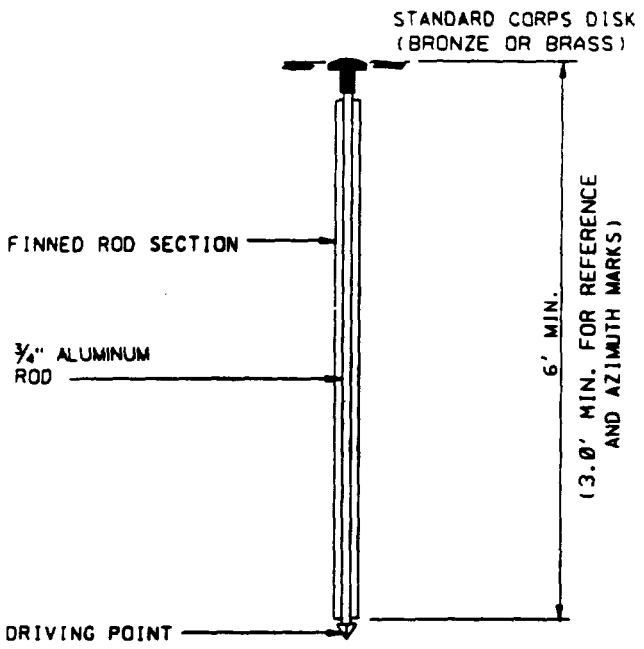
Figure 3-5. Type D monument - deep rod - frost resistant in permafrost



ANCHORAGE BELOW PERMAFROST

USE FOR VERTICAL AND HORIZONTAL CONTROL

Figure 3-6. Type E monument - deep rod - frost resistant below permafrost



USE FOR HORIZONTAL, BOUNDARY, REFERENCE AND AZIMUTH CONTROL

Figure 3-7. Type F monument - disk on shallow rod

An example is a deep well casing. It would resist not only near-surface movements but also, to a degree, movements originating in the subsurface, such as subsidence from pumping. A good illustration of this can be seen in Santa Clara Valley, California, where well casings project prominently because of ground subsidence. These settings should not be ignored simply because a disk cannot be mounted on them. Settings of this type may furnish excellent references for elevations, provided they extend at least three times as deep as the required sleeve depth for a Type B rod mark in that area. It is important to select a good point of reference for the elevation of this type of bench mark. A prominent protrusion can be used if it is definite and has a good high point on which to rest a rod. Alternatively, a cross may be etched with deep, fine lines on a spot accessible to a leveling rod or tape. If possible, stamp or etch the bench mark designation and year nearby.

3-2. Construction and Installation Procedures. All USACE survey disks and access covers shall be stamped using 3.17-millimeter (1/8-inch) steel dies. All stamping shall deform the disk surface by a minimum of 1 millimeter (0.0394 inch).

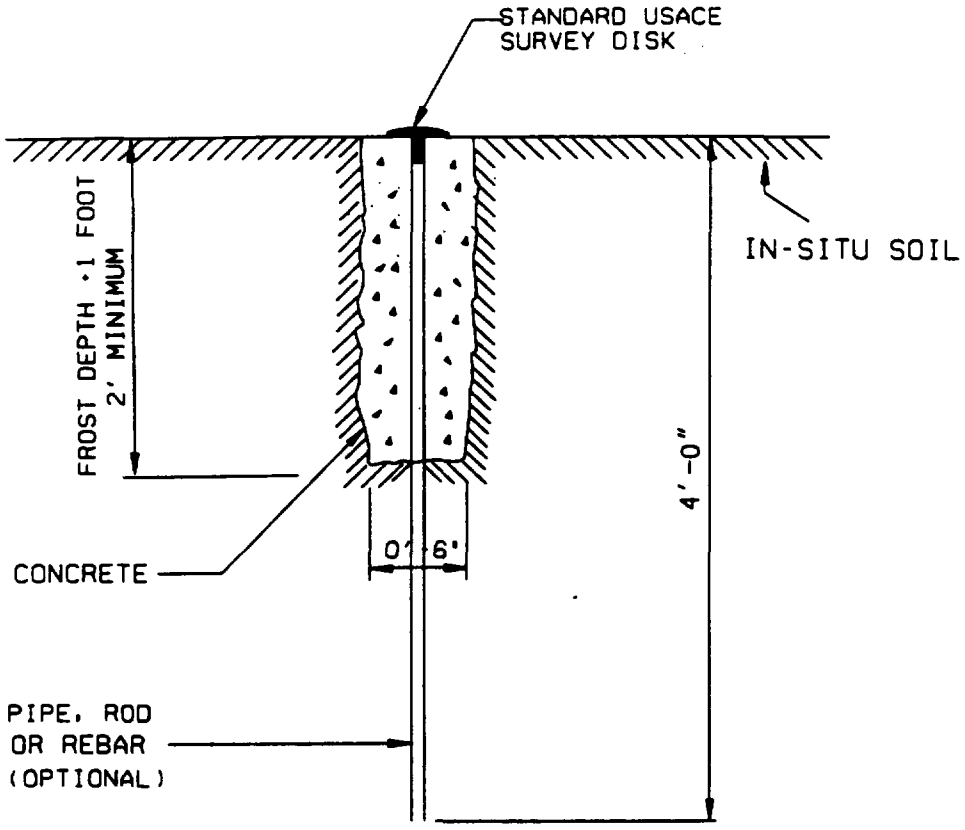


Figure 3-8. Type G monument - disk in cast-in-place concrete

a. Type A - Deep Rod - Aluminum with Finned Section. The construction details are shown in Figure 3-1. The mark is assembled from 3- and/or 4-foot sections of 3/4-inch aluminum alloy rod. The casement is constructed of a 15.2-centimeter (6-inch) PVC pipe 0.6 meter (24 inches) long, fitted with an aluminum access cover at the top. The access cover is imprinted with the information shown in Figure 3-9. The mark name shall be stamped on the access cover at "Mark Designation." The cover and pipe are placed around the top of the mark. Approximately 20 liters (2/3 cubic foot) of concrete is poured around the PVC pipe and access cover to hold them in place and to aid in recovery. The top 4-foot rod section is finned to provide horizontal stability. This type of monument is designed to prevent near-surface soil movements from disturbing the monuments. The rod assembly is driven or pressed to refusal into the soil so that it is anchored below the layers of disturbance. Refusal is defined as the depth at which the rod refuses to drive further or until a driving rate of 60 seconds or less per foot is achieved with a power reciprocating rod driver such as a Pionjar Model 120 or similar device

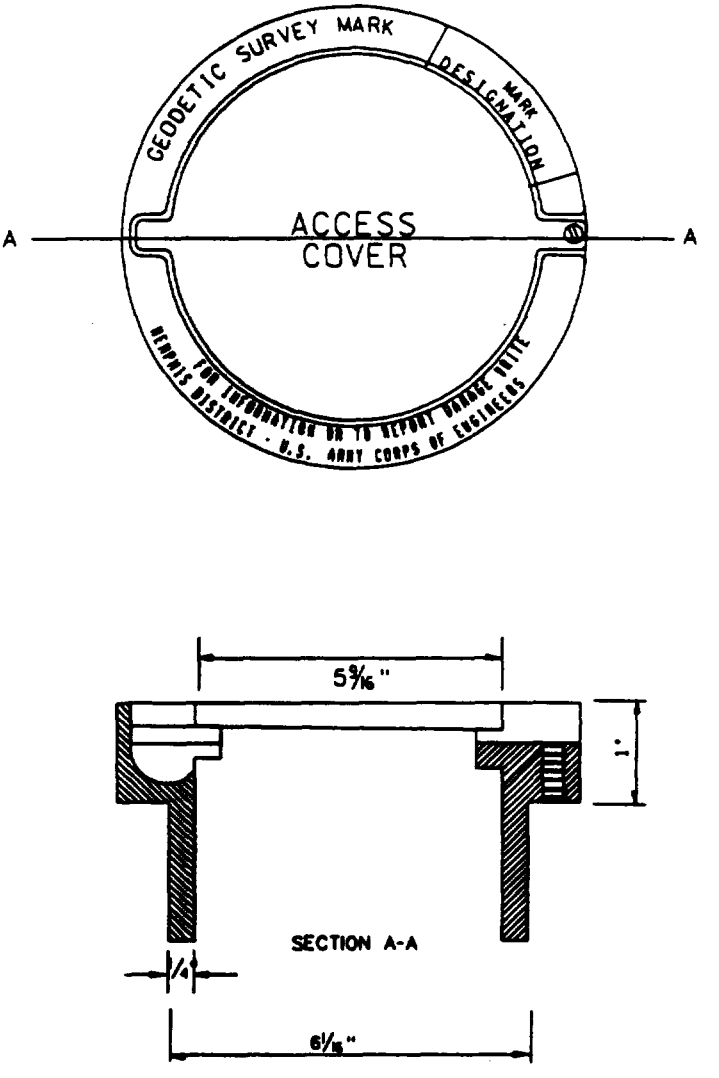


Figure 3-9. Standard access cover

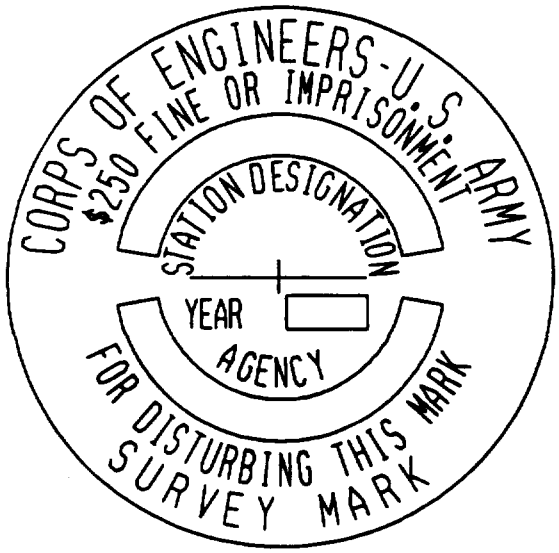
with equivalent driving force of 26.9 foot-pounds/blow and an average of 2,500 blows per minute. The procedure for setting a Type A rod mark is as follows:

(1) Using an appropriate solvent for PVC, glue the aluminum flange to one end of a 0.6-meter (24-inch) section of 15.2-centimeter (6-inch) PVC pipe.

(2) Dig a hole 30 centimeters (12 inches) in diameter to a depth of 0.6 meter (2 feet).

(3) Drive the first section of rod in the center of the hole. Make sure it remains plumb while driving. Couple another section of rod tightly to the first and continue to drive the assembly. To obtain tight joints, hand tighten the sections and then apply another one-quarter turn with a wrench or wrenches. Repeat this procedure until the driving rate is near refusal. The last rod section shall be a 3-foot finned rod section driven such that its top is 3 inches below the surface.

(4) Stamp the name and year on the USACE disk (Figure 3-10) and drive the disk onto the rod. The disk should be driven on the rod about 1 inch.



RECESSED LETTERS
3-1/2 INCH DIAMETER
BRASS/BRONZE

Figure 3-10. Standard survey disk

(5) Center the PVC pipe and access cover assembly over the rod. Backfill inside the pipe with sand to about 5 centimeters (2 inches) below the top of the rod.

(6) Mix about 20 liters (2/3 cubic foot) of concrete and place around the outside of the PVC pipe. Finish the top surface of the concrete so that it slopes slightly away from the top of the access cover.

b. Type B - Deep Rod - Stainless Steel with Sleeve. The construction details are shown in Figure 3-2. The rod is assembled from 3- and/or 4-foot sections of 1.43-centimeter (9/16-inch) Type 316 stainless steel coupled with threaded studs of the same material. The rod itself anchors the datum point to

a stable stratum of soil. For the most stable mark, the sleeve is required to isolate the rod from soil movements occurring above the stable stratum. The sleeve may be omitted if no soil movements are expected; however, stability will be reduced. To avoid movements caused by frost heave and soil shrinking and swelling, extend the sleeve to the maximum depth to where these types of soil movements are expected to occur. The procedure for setting a Type B rod mark is identical to that of the Type A rod mark with the exception of the sleeve and the finned section.

(1) Using an appropriate solvent cement for PVC, glue the aluminum flange to one end of a 0.6-meter (24-inch) section of 15.2-centimeter (6-inch) PVC pipe.

(2) Construct the sleeve by gluing a PVC cap, with a drill hole of adequate diameter to accommodate the rod, on each end of a 1-meter (3-foot) or longer section of 2.54-centimeter (1-inch) schedule 40 PVC pipe. Fill the sleeve with an insoluble, non-corrosive, cold weather type grease.

(3) Dig a hole 30 centimeters (12 inches) in diameter to a depth slightly greater than 1 meter (3 feet) or the depth required to place the sleeve pipe base 30 centimeters (1 foot) below the frost line.

(4) Taking care not to deform its end, by using a drive adapter, drive the first section of 1.43-centimeter (9/16-inch) stainless steel rod down to just above ground level. Make sure it remains plumb while driving. Couple another section of rod tightly to the first and continue to drive the assembly as noted in paragraph 3-2a.

(5) Insert the capped 1-meter (3-foot) or longer grease-filled section of 2.54-centimeter (1-inch) PVC pipe over the 1.43-centimeter (9/16-inch) rod. The PVC sleeve should extend at least 30 centimeters (1 foot) below the local frost line if the frost line is deeper than 90 centimeters (3 feet). The rod should protrude approximately 5 centimeters (2 inches) above the sleeve.

(6) Stamp the name and year on the survey mark disk (Figure 3-10) and drive the disk onto the rod.

(7) Backfill around the outside of the sleeve with sand to about 60 centimeters (24 inches) below ground. Install the 0.6-meter (24-inch) section of 15.2-centimeter (6-inch) PVC pipe with aluminum access cover over and around the sleeve and rod.

(8) Backfill the inside of the 15.2-centimeter (6-inch) PVC pipe with sand around the outside of the sleeve and rod to about 2.54 centimeters (1 inch) below the top of the sleeve.

(9) Pour concrete around the outside of the pipe and finish as outlined in paragraph 3-2a.

c. Type C - Disk in Bedrock or Concrete Structure. The Standard USACE disk (Figure 3-10) is made of brass or bronze. It is 8.9 centimeters (3.5 inches) in diameter with a spherical surface to support the foot of a leveling rod. Information is printed on this surface to identify the monument and to aid the user in obtaining important data. So as not to interfere with placement of the leveling rod, logo information is recessed in the surface of the disk. A deformed shank, about 7.5 centimeters (3 inches) long, is attached to the bottom surface of the disk to help prevent the disk from being dislodged from the monument. In addition, disks with tubular shanks are used when driven on rod marks. The step-by-step procedure for setting the disk in bedrock is as follows:

(1) Stamp the designation and year on the top surface using 3.17-millimeter (1/8-inch) steel dies.

(2) Pick a fairly level and accessible spot on the outcrop that is intact with the bulk of the rock.

(3) Drill a hole 2.5 centimeters (1 inch) in diameter about 10 centimeters (4 inches) deep into the bedrock. Recess the area around the top of the hole to a diameter slightly larger than that of the disk. When the installation is completed, the top surface of the disk should set level and flush with the surrounding rock. Caution: Safety goggles should be worn when drilling into bedrock or masonry.

(4) Remove any rock powder from the hole and recessed area. Fill the drilled hole with clean water and then pour in the epoxy or non-shrink grout. Mixing of the ingredients may be done in the hole. Premixed grout may be used if desired. By adding more water and grout, mix enough grout so that an extra amount is available for the underside of the disk and, if applicable, the inside of the shank. A properly mixed grout should be thick but still workable.

(5) Fill the depression on the underside of the disk with the additional grout. If the disk has a tubular shank, fill the shank with grout. This step is very important; it will prevent highly undesirable voids under the disk once it is in place.

(6) Place the shank of the disk into the drilled hole and press the mark firmly into place. Work the excess grout completely around the outer edge of the disk, making sure that it is smooth and flush with the top surface. An exposed edge of the disk would provide an area that could be used by someone to dislodge the disk. Excess fresh grout on the upper surface of the disk can easily be cleaned off.

(7) Sprinkle some dry cement on the exposed surface of the disk; then rub it with a clean rag using circular strokes. This will clean the disk very nicely, removing all excess grout from its surface and recessed letters. Rubbing the wet grout around

the edge of the disk in the same manner will do no harm. In fact, this is often done intentionally to finish its surface and prevent cracking. Brush away loose cement and make sure that the finished product has a very neat appearance.

(8) To prevent heavy rains from ruining its surface and/or to prevent the disk from being tampered with, the grout must be covered until it is set and dry. A piece of wood, cardboard, heavy paper, or any other similar biodegradable material will suffice.

(9) The installation is not complete until all accumulated trash has been picked up. Leave the monument location in a neat and orderly appearance.

When setting a disk in a massive concrete or masonry structure, first make sure the structure is stable. The required foundation depth is at least equal to a quarter of the specific sleeve depth of a Type B mark (Figure 3-2). The disk may be mounted vertically in a wall of a structure but should be set horizontally if possible. The procedure for setting a disk horizontally in a structure is identical to that for setting one in bedrock. Again, make sure safety goggles are worn when drilling into masonry or concrete. For a vertical setting, the hole for the disk's shank must be drilled horizontally; therefore, the mortar must be mixed separately. When drilling into brick or other soft material, a hammer and star drill should be used rather than heavy power equipment. This prevents the possibility of extensive damage to the exterior. The inside of the drilled hole should be wetted before any mortar is applied. After placing the shank of the disk into the mortar-filled hole, the disk should be worked to the bottom edge of the hole. This will prevent the possibility that the disk will settle askew while the mortar is curing.

d. Type D - Deep Rod - Frost Resistant (Anchored in Permafrost). Construction of this type of monument should be accomplished when the ground is frozen. Plywood should be used in the work area to minimize surface disturbances that destroy the organic mat around the bench mark leading to deepening of the active frost layer and possible instability of the monument. The installation of this bench mark design is outlined below.

(1) Carefully position the drill rig so that disturbance of the moss cover will be kept to a minimum. Place a suitable length of NX (4-inch) casing through the active layer into the perennially frozen ground to prevent thawed material and surface water from entering the hole. Drill a hole to a depth of 39 feet with AX (2-inch) size drill equipment, using an AX core barrel if samples are desired; otherwise, use an AX non-coring bit. If caving occurs, AX drill casing should be placed to the bottom of the hole. When the hole is completed, bail out all the water.

(2) Connect the drive point to a section of 9/16-inch stainless steel or aluminum rod and lower it into the hole to a depth of 8 feet. String a 10-foot length of 1-inch pipe over an 11-foot length of the rod. With vice grips or another device securely clamped to the top of the inner pipe to prevent it from sliding out of the 1-inch casing, raise the two pipes vertically above the hole and connect the rods. Retaining a hold on the outside pipe, lower the assembly into the hole, adding successive sections of rod and 1-inch pipe until the drive point rests on the bottom. Secure the 1-inch pipe so that it projects about 6 inches above the ground. The inner pipe should protrude above the outer pipe.

(3) Holding the pipes in this position, carefully backfill the hole with a sand-slurry mix so that it just pours easily. If drill casing has been used, withdraw it carefully so that the relative positions of the bench mark rod and pipe are maintained as the hole caves in around them. To ensure that the lower portion of the datum pipe is adequately surrounded by soil, it may be necessary to fill the lower part of the hole with the slurry before removing the drill casing. If this is the case, even greater care is required to maintain the relative positions of the bench mark rod and pipe as the drill casing is removed.

(4) Remove the NX casing from the active layer and backfill the hole to the ground surface, carefully replacing the moss cover around the pipes.

(5) Fill the annular space between the inner and outer pipes with an SAE 80 gear oil or a special wax-oil mixture. This mixture can be made up of 70 percent oil (such as Mentor 29) and 30 percent wax (such as Socony Mobil Cerise AA) by weight, mixed after heating to about 200°F. The mixture is poured into the assembled sections of pipe and allowed to congeal before the pipes are placed in the drill hole.

(6) Install the "spring bushing" inside the top of the 1-inch pipe casing. The top of the rod shall be rounded to provide a single point of contact. Center punch the datum point for a three-dimensional monument.

(7) A 4-foot length of 4-inch pipe with pipe cap shall be driven into the ground over the bench mark assembly to provide protection.

e. Type E - Deep Rod - Frost Resistant (Anchored Below Permafrost). Construction of this type of monument should be accomplished when the ground is frozen. Plywood should be used in the work area to minimize surface disturbances that destroy the organic mat around the bench mark leading to deepening of the active frost layer and possible instability of the monument. The installation of this bench mark design is outlined below.

(1) Following the same procedures given above, drill an AX hole to a depth 5 feet below the perennially frozen layer.

(2) If the unfrozen soil underlying the permafrost is relatively soft, complete the installation by driving the 2.54-centimeter (1-inch) pipe and the rod to refusal; then retracting the 2.54-centimeter (1-inch) pipe 0.6 meter (2 feet) above the refusal point.

(3) If the unfrozen soil is stony or very stiff, it may be necessary to extend the borehole to bedrock or other resistant material. In this case, the installation may then be completed by following the procedures used for anchoring bench marks in permafrost previously discussed.

f. Type F - Shallow Rod - Finned, No Casing. The construction details are illustrated in Figure 3-7. The Type F mark is constructed of two 90-centimeter (3-foot) aluminum alloy finned rod sections with a USACE disk driven on the top section. The rods are driven or pressed into the soil such that the USACE disk is flush with the ground surface.

g. Type G - Disk in 3/4-inch Pipe or on Rebar. The construction details are illustrated in Figure 3-8. The Type G mark is constructed by excavating a 15-centimeter (6-inch)-diameter by 60-centimeter (2-foot)-deep hole. In areas where the maximum frost depth is greater than 2 feet, the excavated depth should be 1 foot below the maximum frost depth. The USACE disk may be driven into a 4-foot by 3/4-inch diameter pipe or on a 4-foot by No. 5 reinforcement steel bar (rebar). The pipe or bar assembly is then driven into the center of the hole until the disk is slightly above the surface. The hole is then filled with concrete to the disk. The use of a pipe or rebar is optional. The disk may be pushed directly into the fresh concrete; however, a magnet shall be placed in the concrete if pipe or rebar is omitted.

3-3. Naming Vertical Control Monuments. A vertical control point, commonly referred to as a "bench mark" (BM), should be identified by a number or by an alphanumeric symbol stamped on the respective disk marker (or otherwise inscribed on the bench mark monument or access cover). In principle, the name that identifies a vertical control point for publication purposes should be the same as the name that actually appears on the marker. However, extraneous information, which is not part of the name, frequently appears on the marker. For example, the name of a bench mark should not include the elevation. The name does not generally include the "year mark set". Tidal and water level stations should also be named in accordance with these instructions.

a. Maximum Character Length. A bench mark name must not exceed 25 alphanumeric characters (including all imbedded

blanks). Abbreviate and/or edit a name as necessary to conform to this limit.

b. Organization Acronym. A name should always include the acronym or abbreviation of the agency or organization that set the mark if it is not precast or stamped on the survey marker (for example, USE for U.S. Engineers). In addition, a District or Division acronym may also be included as part of the name if it is not precast or stamped in the marker. The agency and/or organization acronym should not be stamped on the disk as part of the name. However, they may be appended to the name for publication.

Example Names

2903
V 16 RIRR

c. Special Characters. The only special characters permitted in a bench mark name are the blank ( ), plus (+), minus or hyphen (-), equals (=), slash (/), and decimal point (.). When used, these special characters must not be separated from adjacent characters by any blanks. Commas and parentheses are not allowed to appear in a bench mark name.

Example Names

CH 1174=297+00 A
H 23

d. Character Groupings. All alpha and numeric character groupings in a name must be separated by a blank. Care should be taken that only one blank is used for this purpose. Two blanks in a row will be interpreted as the end of the name.

Example Names

MEM 123 B
BEALE 17 B
TT 1 7 B

e. Unacceptable Names. The characters "NO" or "NO." should not be included in the name when used as the abbreviation for the word number. A period may not appear imbedded in or adjacent to a grouping of alpha characters. However, a decimal point may appear imbedded in, or adjacent to, a grouping of numeric characters. Non-specific descriptive terms such as "bench mark," "BM," "chiseled square," "bolt," "red," "nail," or "spike" should

3-5. Witness Posts and Signs. In order to aid in the preservation and to serve as a means of easy recovery of monuments being established, a witness post should be set adjacent to the monument or near one of the reference marks at each station. This post should be 1.8 meters (6 feet) in length and be set to a minimum of 1 meter (3 feet) above the ground surface. The post should have the standard witness post sign attached (Figure 3-11). Witness posts shall be set for monuments of third-order accuracy and above, established along public highways, in rural districts, along the rights-of-way of railroads, and along the shorelines of rivers and lakes. They need not be set for monuments established along business streets, in residential sections of cities, on the grounds of a school or a church, in cemeteries, in cultivated farmlands, or on bare mountain tops. For survey monuments established below grade or in cultivated fields and marked with an underground mark, the post shall be set at a reference mark.

not be used as part of the name. The elevation should not be stamped on the disk marker or otherwise inscribed on the bench mark monument.

Acceptable Example Names

MI 14.2
4419.
PALMER NE BASE

f. Multiple Names. For bench marks that carry multiple stamped names, the information imprinted should be concatenated with the equal sign (=) used as a separator (subject to the 25-character total length limit).

Example Names

H 13=872 2621 TIDAL USE
STA 3=MI 182.5 USE
LEE RM 1=R 13 USE

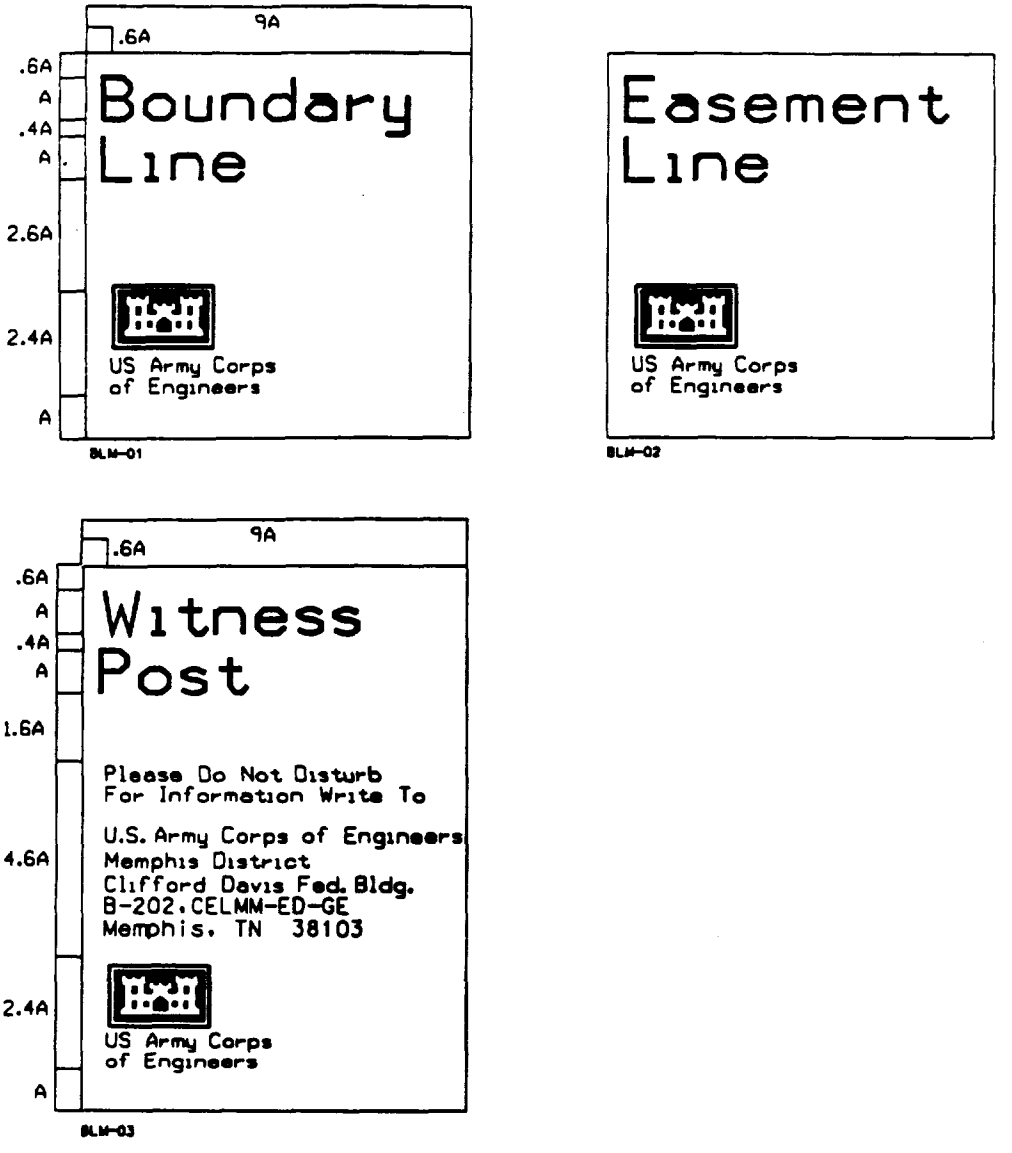
g. Reset Names. When resetting marks, always use a new unique name for each station reset. Do not use "Reset" as part of the name.

h. Temporary Bench Marks. A temporary bench mark (TBM) must carry the letters "TBM" as the first three characters of the name.

Example Names

TBM 1 A
TBM 14

3-4. Marks of Other Organizations. If a satisfactory vertical control monument of another organization is found at the project site in good condition, it may be used without alteration as the station mark of a new USACE Survey Monument. In case the existing mark of the other organization is not in good condition for a station mark, a new station mark should be established in the vicinity, and the mark of the other organization should be used as an extra reference mark. The stamping of additional marks should be done as indicated in this manual. Care should be taken not to displace a mark of another organization in horizontal position, or even in vertical position if there is a possibility that it could be used as a bench mark. The mark should not be altered without permission from the organization that established it.



SIGN TYPE	LEGEND SIZE (A)	PANEL SIZE	POST SIZE	SPECIFICATION CODE	MOUNTING HEIGHT	COLOR BKG/LGD
BLM-01	.3437	3.5"x3.5"	4"x4"	SCP-7	36" MIN.	WH/BK
BLM-02	.6875	6"x6"	4"x4"	SCP-7	36" MIN.	WH/BK
BLM-03	.3125	2.875"x2.875"	3.75"x.5"	SCP-10	36" MIN.	WH/BK

Figure 3-11. Standard property markers

CHAPTER 4

HORIZONTAL CONTROL MONUMENTS

4-1. Selection of Monument Type Based on Local Site Conditions. Types of monuments to be used for horizontal control are a function of the order of accuracy of the survey, of the intended use of the data collected, and of the location provided. The various monuments that should be used to provide horizontal control only are identified in Table 4-1. The site selection criteria have previously been discussed in paragraph 3-1. If higher order accuracy other than that illustrated in Table 4-1 is desired, then a Type A rod mark should be used. High precision engineering and deformation studies require extremely stable monuments, i.e, instrument pedestals and force-centering devices. Other rod type monuments in this manual may also be used for horizontal control as well as vertical control.

4-2. Construction and Installation Procedures. Construction details for rod marks have been previously discussed in paragraphs 3-2a. through 3-2g. Instrument pedestals shall be

Table 4-1

Site Conditions and Monument Types for Horizontal Control

Site Conditions	Order of Accuracy			
	High	1	2	3
Rock outcrops, large boulders, bedrock concrete structures (more than 5 years old)	C	C	C	C
Granular soils (sand and gravel)	G	G	G	F,G
Glaciated soils (till)	G	G	G	F,G
Fine-grained soils (silts and clays with high bearing strengths)	G	G	G	F,G
Fine-grained soils (silts and clays with low bearing strengths)	G	G	G	G
Construction fill (disturbed earth)	G	G	G	G
Permafrost	E	E	D	G
Marsh	A,B	A,B	A,B	A,B
Subsidence area	A,B	A,B	A,B	A,B

constructed as shown in Figure 4-1. The centering device should be constructed as outlined in Figures 4-2 and 4-3 and should have a protective cover. It is recommended that soil and/or geotechnical specialists be consulted prior to construction of instrument pedestals. All USACE survey disks and access covers shall be stamped using 3.17-millimeter (1/8-inch) steel dies. All stampings shall deform the disk surface by a minimum of 1 millimeter (0.039 inch).

a. Pedestal in Soil. For a monument pedestal in soil (Figure 4-1a), a 1.2-meter (4-foot) square concrete footing shall be constructed below the frost line. The thickness of the footing will be 0.6 meter (2 feet). A 25.4-centimeter (10-inch)-diameter steel pipe pedestal filled with concrete will be attached to the footing with five #4 ribbed rebars placed on 10-centimeter (4-inch) centers embedded in the footing and pedestal for a minimum of 50 centimeters (20 inches). A centering device as shown in Figures 4-2 and 4-3 shall be placed in the center of the pedestal. A protective cover and casing of 45.7-centimeter (18-inch)-diameter steel pipe shall be placed over the pedestal and extended from the top of the footing to approximately 1.22 meters (4 feet) above the ground surface.

b. Pedestal on Rock. For a control monument on rock, the construction is similar to the construction for a control monument in soil as illustrated in Figure 4-1b. All fractured and weathered material shall be removed from the rock. Then the rebars shall be epoxy grouted into the top of sound rock with five #4 ribbed rebars on 10-centimeter (4-inch) centers. The rebar shall be epoxy grouted into the rock for a minimum distance of 50 centimeters (20 inches) and should extend into the bottom of the pedestal at least 25 centimeters (10 inches). The protective covering, casing, pedestal, and centering device will be constructed in the same manner as a control monument in soil.

c. Centering Devices. The forced centering device shown in Figure 4-2 shall be installed in the top center of the instrument pedestal. The bottom of the centering device shall be embedded 5.7 centimeters (2.25 inches) in the concrete. The forced centering device shown in Figure 4-3 attaches to the base of the instrument and forces the instrument to center on the pedestal device.

d. Structure Insert. A structure insert is grouted in the existing concrete structure at selected locations (Figure 4-4). The top surface is rounded to provide a point for precise leveling. The center is tapped and threaded to fit a standard prism 5/8-inch by 11-inch thread. A 5/8-inch brass plug or bolt should be screwed into the threads when not in use. The insert shall be made from 1-1/4-inch hex stainless steel stock. The structure insert is illustrated in Figure 4-4.

4-3. Naming Horizontal Control Monuments. Intelligible names should be assigned as primary identifiers of horizontal control

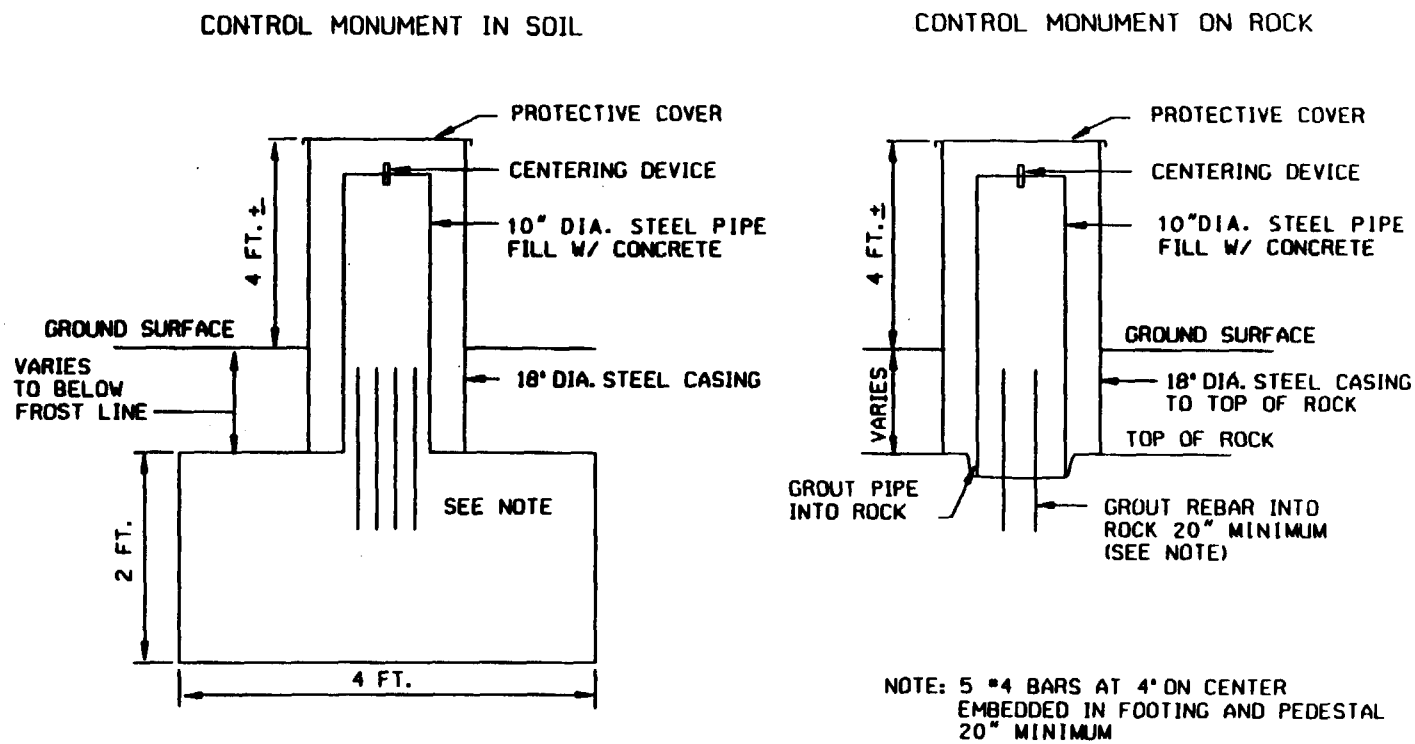


Figure 4-1. Instrument pedestal

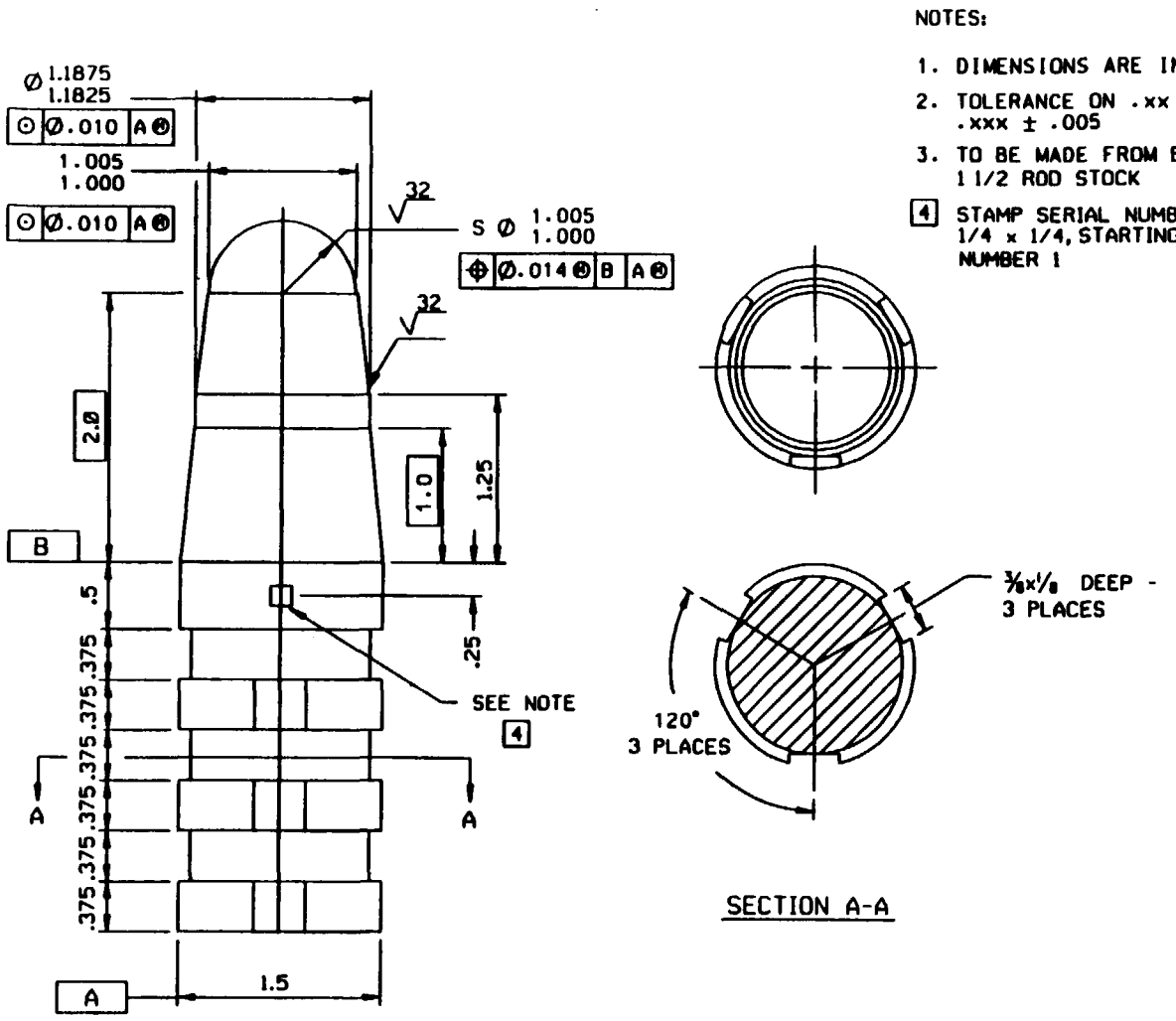


Figure 4-2. Instrument pedestal forced centering device

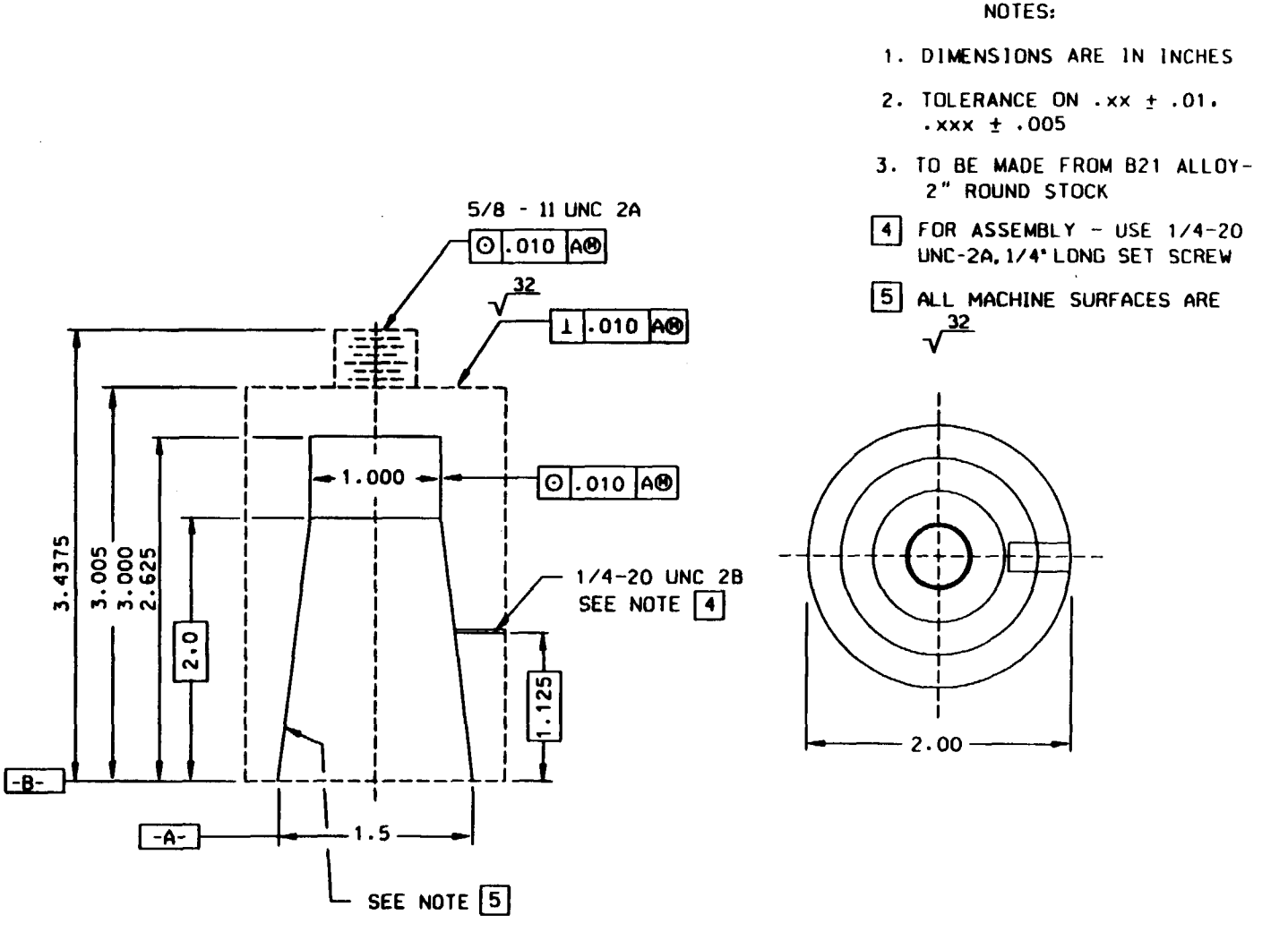


Figure 4-3. Instrument forced centering device

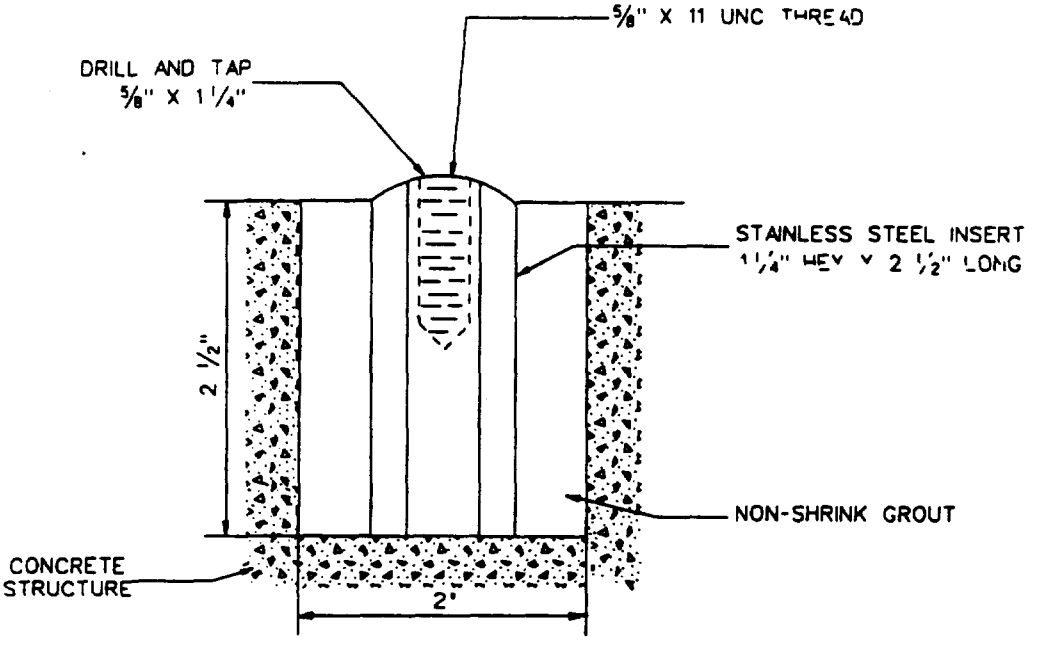


Figure 4-4. Structure insert

points. A properly chosen station name should in itself be descriptive and/or indicative of the general location of the respective horizontal control point.

a. Maximum Character Length. The name of a monumented horizontal control point should be concise, being limited in length to a maximum of 30 characters.

b. Monumented Point. In addition to the "year mark set" another date is associated with every survey point whether it is a monumented horizontal control point or an unmonumented recoverable landmark. This additional information, referred to as the "year established," is the year in which observations were first performed for the purpose of determining the position of the horizontal control point. The "year established" should also reflect the year in which the original description of that control point was prepared. The "year established" and "year-mark-set" of a monumented horizontal control point are often identical. Additional information on network design, geometry, and connections is located in a separate engineering manual that is currently in preparation.

c. Unmonumented Point. Another type of horizontal control point is an unmonumented recoverable landmark such as a flagpole or church spire. The name of a horizontal control point of this type must be sufficiently descriptive in order to identify the respective landmark (frequently a specific feature of the landmark). For this reason, the name of this type of control point is usually lengthy. The length of a station name, including all imbedded blanks, should be limited to 30 characters. The same limit applies to the name or designation of a reference mark (RM) or azimuth mark (AZ MK). Accordingly, the name of every horizontal control point, as well as the name or designation of an RM or AZ MK, should be abbreviated so that it does not exceed 30 characters.

d. Abbreviating Lengthy Names. When a lengthy name of a horizontal control point is contracted to the 30-character limit, the abbreviation and/or editing of the station name should be accomplished with due regard to the following fact. The names of reference and azimuth marks should be formed by appending the symbols RM 1, RM 2, ..., RM 13, etc., and AZ MK (possibly AZ MK 2, AZ MK 3, etc.) to the station name of the control point. For this reason, the name of a horizontal control point that has peripheral reference marks and/or azimuth marks may have to be further contracted to 24 characters (possibly less). This contraction is necessary to allow the reference and azimuth mark names to conform to the 30-character limit. The abbreviation "ECC." (for eccentric) should never be stamped on a disk. Each standard disk utilized to mark a horizontal control point should be stamped with the station name, year set, and organization (District) designated on the marker. Each recorded station, which is re-marked, should be stamped with the original name of the station, the original date of establishment, and the year in which it is reset. All information imprinted on any disk used for station and reference marks should be stamped with 3.17-millimeter (1/8-inch) dies.

4-4. Reference and Azimuth Marks. Reference and azimuth marks should be constructed similar to their respective control monuments. Type F and Type G monuments (Figures 3-7 and 3-8) may be used as reference and azimuth monuments. However, these types of marks need only extend a minimum of 91 centimeters (3 feet) below natural ground. In areas having permafrost, marks should be anchored about 60 centimeters (2 feet) in the permafrost. Reference marks and azimuth marks should be identified by standard USACE disk markers with an arrow as the survey point symbol created by stamping a "V" on either end of the line indicating the center. The markers are set in such a way that the arrow points toward the respective horizontal control point. Three reference marks should be established for first- and second-order control networks in the immediate vicinity (less than 30 meters (100 feet)) of a monumented horizontal control point. The reference marks may be natural landmarks or manmade monuments. In addition, if a well-defined permanent object (natural or manmade) is not available, one azimuth mark shall be established for

first- and second-order control networks not less than 0.4 kilometer (0.25 mile) away when feasible. This will provide an azimuth reference point that is visible from ground level at the horizontal control point. Azimuth and reference marks are not required for third-order networks or when adjacent control points have intervisibility and are not closer than 0.4 kilometer (0.25 mile). Vertical and horizontal control type monuments may be used for reference and azimuth marks.

a. Naming Reference Marks. The originally established reference marks of a horizontal control point should be assigned sequential numbers (for example, NO 1, NO 2, etc). Any subsequently established reference mark should be assigned the next unused number in the sequence, even if one or more of the previously established reference marks may have been destroyed. The standard practice is to stamp the name of the horizontal control point to which a reference mark refers above the arrow (station designation) that appears in the center of the disk marker. The number of the reference mark, NO 1, NO 2, etc., is stamped immediately below the arrow. The year in which the reference mark was set is stamped in the block marked "year." The name or designation of a reference mark (RM) must not exceed 30 characters in length. It should normally consist of the name of the horizontal control point to which the respective RM belongs with the symbol RM 1, RM 2, ..., RM 13, etc., appended for reference marks NO 1, NO 2, ..., NO 13, etc. No additional information should be added to the name of an RM, except when the numbering system described above has not been followed, or when two or more reference marks associated with a horizontal control point have identical names. In this case, the "year mark set" should be further appended to make the respective names unique (for example, KELLEY RM 1974 and KELLEY RM 1975, if the RM set in 1975 has not been stamped "NO 2"). Considering that the total length of RM name must not exceed 30 characters, the name of the horizontal control point must itself be limited to 24 characters to allow for any appended symbols (RM 1, RM 2, etc.). The name of the horizontal control point must be taken as it appears on the disk, except for possible further abbreviation and/or editing that may be required. If old reference marks are found to be in poor condition, they should be destroyed and reset. The new reference mark should be numbered with the next consecutive unused number, regardless of the existence or absence of any of the reference marks.

b. Naming Azimuth Marks. The same procedures used to name reference monuments shall be used for azimuth marks. If more than one azimuth mark is involved, a number should be assigned and stamped on the azimuth disk marker. Symbols such as AZ MK should be appended to the control point designation when only one azimuth mark is present. Symbols such as AZ MK 2, AZ MK 3, etc., should be appended when two or more azimuth marks are installed. The complete designation station name plus AZ MK 2, etc., shall not exceed the 30-character limit.

c. Other Agency Monuments. Occasionally, an existing monumented survey point of another agency may be used for a reference mark or, more frequently, for an azimuth mark. Such a survey point must be treated as a control point. If it can be positioned, or if its geodetic position is available from other sources, this data should be provided in the description; otherwise, give its name or designation.

4.5 Three-Dimensional Monuments. With the increasing use of space system measurement techniques, such as the Navstar Global Positioning System (GPS), it is important that station markers be stable in all three dimensions (Three-Dimensional Monuments). When selecting sites for high precision primary networks or for deformation monitoring, it is recommended that soil and geotechnical specialists be consulted. The type monument best suited for a given condition will depend on factors previously discussed. To meet the requirements of permanent and stable monumentation, the three-dimensional monuments should be metal disks set in rock outcrops or large masses of concrete, Type C (Figure 3-3), and deep-driven rod monuments, Types A and B (Figures 3-1 and 3-2). The name or designation of individual monuments used for both horizontal and vertical control networks of third order or better should be limited to 25 characters. Neither the "year established" nor the "year mark set" should appear as a part of the station name. Designation criteria for vertical control monuments, as outlined in paragraph 3-3, should also be used for all three-dimensional monuments.

4-6. Marks of Other Organizations. If a satisfactory horizontal control monument of another organization is found at the project site in good condition, it may be used without alteration as the station mark of a new USACE Survey Monument. Reference marks and azimuth marks should be placed, as necessary, to bring the station installation up to the requirements of this manual. In case the existing mark of the other organization is not in good condition for a station mark, a new station mark should be established in the vicinity, and the mark of the other organization should be used as an extra reference mark. The stamping of additional marks should be done as indicated in this manual. Care should be taken not to displace a mark of another organization in horizontal position, or even in vertical position if there is a possibility that it could be used as a bench mark. The mark should not be altered without permission from the organization that established it.

4-7. Witness Posts. In order to aid in preservation and to serve as a means of easy recovery of monuments being established, a witness post should be set adjacent to the monument or near one of the reference marks at each station. This post should be 1.8 meters (6 feet) in length and be set to a minimum of 1 meter (3 feet) above the ground surface. The post should have the standard witness post sign attached (Figure 3-11). Witness posts will be set for monuments of third-order accuracy and above, established along public highways, in rural districts, along the

rights-of-way of railroads, and along the shorelines of rivers and lakes. They need not be set for monuments established along business streets, in residential sections of cities, on the grounds of a school or a church, in cemeteries, in cultivated farmlands, or on bare mountain tops. For survey monuments established below grade or in cultivated fields, the post shall be set at a reference mark.

CHAPTER 5

BOUNDARY MONUMENTS

5-1. Installation of Boundary Monumentation. The installation and the types of monuments used for boundary monumentation should be under the control of the Real Estate Division. Site conditions, the value of the property, the legal description of the property, encroachment possibilities, and local laws and customs are some factors that dictate the economics and practicality of where and what type of monument should be installed. In the absence of specific instructions from the Real Estate Division, the criteria presented in this chapter are offered as guidance.

5-2. Selection of Monument Type Based on Local Site Conditions. The type of monument to be used for boundaries is a function of the site conditions. The different monuments that may be used to mark boundaries are identified in Table 5-1. Construction details are illustrated in Figures 3-1, 3-3, 3-7, and 3-8. All boundary monuments shall be constructed with the standard USACE survey disk.

Table 5-1

Site Conditions and Monument Types for Boundary Control

Site Conditions	Monument Types
Rock outcrops, large boulders, bedrock concrete structures (more than 5 years old)	C
Granular soils (sand and gravel)	F,G
Glaciated soils (till)	F,G
Fine-grained soils (silts and clays with high bearing strengths)	F,G
Fine-grained soils (silts and clays with low bearing strengths)	G
Construction fill (disturbed earth)	G
Permafrost	G
Marsh	A
Subsidence area	A

5-3. Construction and Installation Procedures. The standard USACE survey boundary disk shall be used as boundary monuments constructed as Type C, Type F, or Type G. All USACE survey disks shall be stamped using 3.17-millimeter (1/8-inch) steel dies. All stampings shall deform the disk by a minimum of 1 millimeter (0.0394 inch).

a. Monuments in Concrete or Rock. Refer to Type C monument installation in paragraph 3-2c.

b. Drive-in Aluminum Rod Monuments. The Type F monument is illustrated in Figure 3-7 and constructed as outlined in paragraph 3-2f.

c. Poured-in-Place Concrete. Monuments that are poured in place should be constructed as illustrated in Figure 3-8 for a Type G monument.

5-4. Naming Boundary Monuments. Monuments may be identified by code numbers or alphanumeric symbols as outlined in paragraph 4-3. Monuments may be identified by a name or a designation of a specific corner. All monuments shall be constructed with a USACE survey disk (Figure 3-10) and shall have the right of way (R/W) or boundary stamped thereon.

5-5. Reference Monuments. A reference monument is an accessory and is employed in situations where a regular permanent monument locating the site of a corner cannot be established. Also, reference monuments are required in areas where the corner monument would be liable to destruction and/or bearing trees or nearby bearing objects are not available. When the true point for a corner lies within an unimproved roadway, in such a place as to interfere with travel, an iron rod, pin, or Type F monument shall be buried in the ground at the true corner point. If bearing trees or nearby bearing objects are not available, at least two reference monuments should be established at suitable places outside of the roadway. Allowance should be made for grading, cuts, fills, or other road improvement when placing the reference monuments. If the surface of the roadway is gravel, macadam, or bituminous-topped, approval from the proper authorities should be obtained before placing the point. In the case of a hard surface, a survey disk or "P-K" nail should be placed at the true point. Two reference monuments ordinarily suffice in public survey practice, but four may be employed if desirable. When two monuments are used, they are usually placed equidistant and in opposite directions from the true point. An acceptable alternative is the placement of the monuments so that the lines connecting them with the corner point are approximately perpendicular to each other. If four monuments are used, they should be placed in opposite directions in each of the four quadrants. When the true point is in an engineered road with established right-of-way lines, it is desirable to locate the reference monument on the intersection of those right-of-way lines and the true property

lines that establish the corner point. Appropriate identification, as outlined in paragraph 4-4, shall be utilized.

5-6. Witness Trees and Corners. Each property corner, reference monument and witness corner shall be witnessed by at least three healthy witness (sometimes called "tie" or "reference") trees a minimum of 15 centimeters (6 inches) in diameter and at least 1.2 meters (4 feet) tall. When possible, all witness trees shall be blazed, facing the corner set they reference. Witness trees must also be marked with an x facing the corner at an elevation height of 120 to 150 centimeters (4 to 5 feet) above the ground. Care should be taken to cut the cross to a sufficient depth to leave a set of permanent narrow marks forming a cross with lines about 25 centimeters (10 inches) long. Witness trees to witness corners should be scribed with the symbols W.C. (witness corner). Tree blazing and marking should not be done without the specific permission of the landowner.

a. Witness/Reference/Tie Distance Measurement. All distance measurements shall be horizontal and taken to the center of the tree.

b. Witness/Reference/Tie Directions. The bearing of each distance measurement shall be observed and recorded. A compass is sufficiently precise for this measurement.

c. Witness Corner Monuments. Where physically impossible to set a monument, a witness corner(s) should be set on each converging boundary line, no closer than 150 centimeters (5 feet) from the corner point. All witness corners, identified as W.C., shall be marked with a USACE disk. The distance to the true corner shall be stamped on the disk, along with an arrow indicating the direction.

d. Natural or Physical Monuments. Natural monuments are permanent objects that are works of nature, such as streams, rivers, ponds, lakes, bays, trees, ledges, rock outcrops, and other definitive terrestrial features. A tree standing at a corner may be marked only when permissible. Care should be taken to cause only superficial damage to the tree. Blazing should penetrate the bark and leave an open cut no wider than 8 centimeters (3 inches) and no longer than 25 centimeters (10 inches). Corner trees should be marked with four-way blazes (blazed on all four sides). Trees on a boundary line (line trees) should be face blazed with one hack above and one hack below, on opposite sides of the tree, along a line 120 to 150 centimeters (4 to 5 feet) above the ground. Permission should be obtained before marking any trees. Selected trees within 90 centimeters (3 feet) of the line should be marked with three hacks facing the line and face blazed on opposite sides of the marks 120 to 150 centimeters (4 to 5 feet) above the ground.

5-7. Boundary Marker Sign. In order to aid in the preservation and to serve as a means of easy recovery of newly established

monuments, a 4- by 4-inch wooden post or equivalent marker shall be set adjacent to the station monument or near one of the reference marks of each station (preferably at the station mark). This post should be a minimum of 170 centimeters (5.5 feet) in length and should be set to project a minimum of 90 centimeters (3 feet) above the ground surface. The post should be painted white with a marker having a legend of black letters attached as indicated by the boundary line or easement line markers shown in Figure 3-11.

CHAPTER 6

DOCUMENTATION

6-1. Monument/Marker Documentation. Each permanent monument constructed or recovered should be documented by completing DA Form 1959, Description or Recovery of Horizontal Control Station, illustrated in Figure 6-1.

a. Monument Name. The monument name shall conform to that outlined in the manual and as stamped on the disk. Longitude and latitude shall be scaled from maps for marks with vertical control only. The order of accuracy shall be determined as defined by Federal Geodetic Control Committee specifications. Monument type shall be designated as outlined by this manual. Additional instructions on the completion of DA Form 1959 are located on the back of the form.

b. Computer Data Base Storage. For those using computer data bases for storage and retrieval of control data, a suggested format is illustrated in Figure 6-2. Use of this format is optional and modification of data elements is allowed to meet local needs. Additional instructions on the use of this format are located on the back of Figure 6-2.

SAMPLE

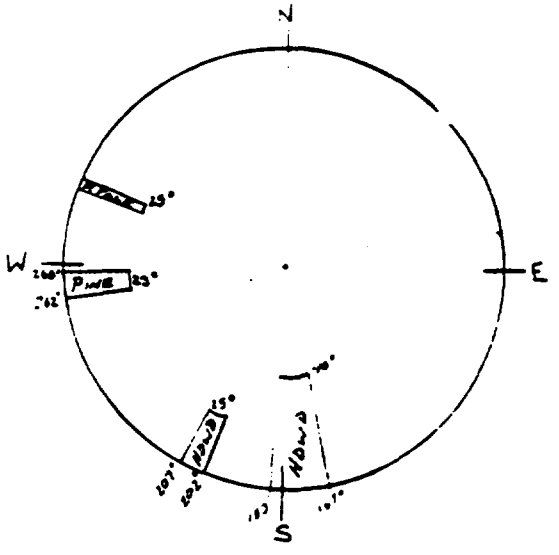
COUNTRY	TYPE OF MARK	STATION	
United States	A (23ft deep)	Q-11-1-89	
LOCALITY	STAMPING ON MARK	AGENCY (CASE IN MARK)	ELEVATION (FT)
Shelby Co., TN	Q-11-1-89	Corps of Engineers Memphis District	272.648
LATITUDE	LONGITUDE	DATUM	DATUM
35-21-14.05966	89-57-09.62619	NAD 83	NGVD 29
[NORTHING] (FT)	[EASTING] (FT)	GRID AND ZONE	ESTABLISHED BY (AGENCY)
395,295.637	790,128.928	Lambert - Tennessee	Memphis District
[NORTHING] (M)	[EASTING] (M)	GRID AND ZONE	DATE / ORDER
3,916,554.324	776,914.451	UTM - 15	11/02/89 / 3rd

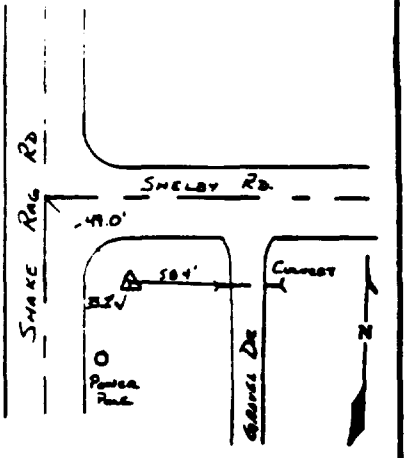
TO OBTAIN Tennessee — GRID AZIMUTH ADD Z 18 50.6 TO THE GEODETIC AZIMUTH

TO OBTAIN UTM-15 — GRID AZ. (ADD/SUB) 1 45 51.8 TO THE GEODETIC AZIMUTH

OBJECT	AZIMUTH OR DIRECTION (GEODETIC/GRID)	BACK AZIMUTH	GEOD DISTANCE (FEET)	GRID DISTANCE (METERS) (FEET)
Q-11-2-89	93° 56' 05".5	93° 56' 14".5	1277.040	TN-1277.002ft
				UTM-389.450m

First Order horizontal control mark was established by the Memphis District Corps of Engineers in November 1989. To reach the station from the intersection of U. S. Hwy 51 and Shelby Road, go West on Shelby Rd. for 2.8 miles to Shake Rag Road and the station on the left. The station is 49.0' SE of the intersection of Shelby and Shake Rag Road, 35.2' NE of a power pole, 58.4' W of the C/L of a gravel drive over a culvert leading to the residence at the site, and 2' N of a witness post. The disk is 0.7' below the surface of the access cover. The access cover is 0.2' below ground level and 0.5' below road level. The disk and access cover are stamped Q-11-1-89.





SKETCH

DA FORM 1959 OCT 86 — REPLACES DA FORMS 1959 AND 1959-1, FEB 87, WHICH ARE OBSOLETE.

DESCRIPTION OR RECOVERY OF HORIZONTAL CONTROL STATION

For use of this form, see TM 5-237; the proponent agency is TRADOC.

Figure 6-1. Description or Recovery of Horizontal Control Station Form (Continued)

S A M P L E

NOTES ON COMPLETION OF FORM

1. GENERAL: This form may be used in the field or, as an office form to record and publish positions, descriptions, and related data.

2. FIELD USE OF FORM: The information required should be obtained and recorded *AT THE STATION SITE*. The field engineer should fill in only the information available and applicable to field use. In general, the geographic and grid positions, azimuths, distances, and elevations should not be filled in at field level except when the information is required for an immediate specific purpose.

a. ORIGINAL DESCRIPTION OF NEW STATION: The type of mark used for the station, reference marks, and azimuth marks, and a description of each must be given in the text of the description. If a disk is used, the identity of the agency whose name is cast in the disk and all of the letters and numbers stamped on the mark which identify the organization establishing or setting the mark should be given. In many areas the use of disks is not desirable because of their loss, due to vandalism or superstition. Less conspicuous marks should be used under these conditions. This requires exact statements of the character of the marks. Information for all marks as to the elevation above or below ground and approximate elevation above or below nearby prominent features is important. At least three measurements within .01 foot should be made from the station to any permanent marks, features, or structures that would permit relocating the spot where an instrument was centered. Good judgment should be exercised as to how far these measurements should be made. It is recommended that they be made to items which are not in the immediate vicinity of the station. Angles should also be turned to these items, particularly where no azimuth mark or marks have been established.

b. VIEW: Provide information on height of tower or stand used in occupying or establishing the station and information on view from a normal tripod, i.e., a 50-foot tower was used at the station; view from a tripod height is clear to the south and east but is obstructed by rise in ground *(by 50 foot trees)* to the north and west.

c. PHOTOGRAPHIC IDENTIFICATION: Provide when possible, two measurements from the station to natural or cultural features which might be visible on aerial photography and a description of the terrain. If photographs are available identify the station thereon and note estimated accuracy of the identification.

d. NOTES ON RECOVERED STATIONS: A diligent search should be made for *ALL* previously established stations in the vicinity and no station should be reported as destroyed unless conclusive evidence of destruction is present. A statement of the diligence of the search and reason for the non-recovery of a previously established mark is required. If the spot where a station mark was located can be reproduced by measurement given in the description, the station is not destroyed. The reproduced spot should be tied in by azimuth and distance and the estimated accuracy of the reproduced location given. If a new mark is set in the exact location of a previously established but destroyed mark, the designation of the station should be identical with the original with only a new date added to its designation. If a new disk is set in the approximate location of the old station, the name should be preserved but the number "2" and a new date should be added.

(DESCRIBED) (RECOVERED) BY	
Carol A. Waite	
PROJECT	
GPS 12 - Big Creek	
DATE	FIELD BOOK
Nov 1989	N/A

* U.S. Government Printing Office: 1985—491-003/42168

Figure 6-1. (Concluded)

MONUMENT/MARKER DOCUMENTATION

1. Name of Monument Q-11-1-89
2. Quad Sheet MILLINGTON
3. City (nearest city, town, community, etc.) SLOANVILLE
4. County SHELBY
5. State TN
6. River *
7. River Mile *
8. Lake/Reservoir *
9. Date established 2 NOV 89
10. Elevation 272.648
11. Latitude 35-21-14.05966
12. Longitude 89-57-09.62619
13. Datum Vertical: NGVD 29 Horizontal: NAD 83
14. Order of Accuracy Vertical: 3rd Horizontal: 1st
15. Monument Type A Type of Rods * 23 ft.
16. Highway/Road * SHELBY
17. Section *
18. Township *
19. Range *
20. Baseline Station *
21. Levee District *
22. Levee Mile Post (LMP) *
23. Railroad *
24. Bayou *
25. Ditch/Creek * BEAR
26. Pumping Station *

* - If applicable

27. Description: TO REACH THE STATION FROM THE INTERSECTION OF US HWY 51 AND SHELBY RD, GO WEST ON SHELBY RD FOR 2.8 MI TO SHAKE RAG RD AND THE STATION ON THE LEFT. THE STATION IS 49.0'SE OF THE INTERSECTION OF SHELBY AND SHAKE RAG RD, 35.2'NE OF A POWER POLE, 58.4'W OF THE C/L OF A GRAVEL DRIVE OVER A CULVERT LEADING TO THE RESIDENCE AT THE SITE, AND 2'N OF A WITNESS POST. THE DISK IS 0.7' BELOW THE SURFACE OF THE ACCESS COVER. THE ACCESS COVER IS 0.2' BELOW GROUND LEVEL AND 0.5' BELOW ROAD LEVEL. THE DISK AND ACCESS COVER ARE STAMPED Q-11-1-89

Sketch

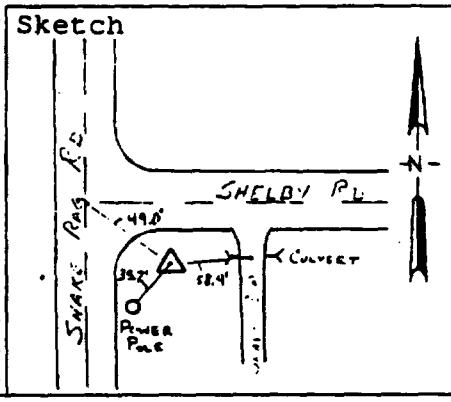


Figure 6-2. Suggested format for monument/marker documentation (Continued)

GUIDELINES ON COMPLETION OF FORMAT

1. General. This format may be used in the field offices to record positions, descriptive and related data, or for direct entry to a database program.

2. Use of Format. Descriptive data and other information available in the field should be recorded at the station site. All other applicable data should be added to the format as this information becomes available. Information equivalent to data items 1 thru 5, 9 thru 15, and 27 should be completed for each mark. All other items should be completed only as applicable.

1. The name or station designation of the mark.
2. The name of the 15-minute quad where the mark is located.
3. The name of the city, town, or community near the mark.
4. The county in which the mark is located.
5. The state in which the mark is located.
9. The month, day, and year the mark was established.
10. The elevation of the top of the disk or rod of the mark. For horizontal-only marks, the elevation should be interpolated to the nearest half meter.
11. The exact latitude (at least three decimal places) of mark. For vertical-only marks, the latitude should be scaled to the nearest second.
12. The exact longitude (at least three decimal places) of the mark. For vertical-only marks, the latitude should be scaled to the nearest second.
13. The datum surface to which the horizontal and vertical positions of the mark are referenced.
14. The order and class of accuracy to which the horizontal and vertical positions were established. State if scaled or interpolated.
15. The single letter designation of the monument type. If metal rods, pipe, or rebar were used, state the depth to which they were driven.
27. The text of the description shall include, but is not limited to the following.
    a. A one-paragraph narrative providing specific directions on how the monument may be reached from a readily locatable landmark, such as a public building in a nearby town or the crossroads of prominent highways.
    b. At the station site, pinpoint the location of the mark with distance and direction from at least three reference objects in the immediate vicinity.
    c. Vertical reference should be provided by giving the mark's distance above, below, or level with a nearby reference object or ground surface.
    d. The distance and direction to the mark from the witness post should be provided.
    e. If disk is used, provide the identity of the agency whose name is cast in the disk and all the letters and numbers stamped on the disk that identify the name of the mark and the organization setting it (i.e. the exact stamping on the disk).

Figure 6-2. (Concluded)